Issued March 1970

SOIL SURVEY

Runnels County, Texas

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
TEXAS AGRICULTURAL EXPERIMENT STATION

Major fieldwork for this soil survey was done in the period 1958–63. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1963. This survey was made cooperatively by the Soil Conservation Service and the Texas Agricultural Experiment Station. It is part of the technical assistance furnished to the Runnels County Soil and Water Conservation District.

Either enlarged or reduced copies of the soil map in this publication can be made by commercial photographers, or they can be purchased, on individual order, from the Cartographic Division, Soil Conservation Service, USDA, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

THIS SURVEY contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, or other structures; and in determining the suitability of tracts of land for farming, industry, or recreation.

Locating Soils

All of the soils of Runnels County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with a number shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in this publication. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, gives the capability unit and range site classifications for each, and shows the page where each range site is described.

Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitation for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with them can learn about use and management of the soils from the soil descriptions.

Ranchers and others can find under "Use and Management of Rangeland" groupings of the soils according to their suitability for range and descriptions of the vegetation of each range site.

Game managers, sportsmen, and others can find information about soils and wildlife habitat in the section "Use of the Soils for Wildlife."

Engineers and builders can find under "Use of the Soils in Engineering" tables that describe soil properties that affect engineering and show the relative suitability of the soils for specified engineering purposes.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Runnels County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "Additional Facts About the County."

Cover picture: Dryland grain sorghum on Rowena and Tobosa soils, 0 to 1 percent slopes.

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Contents

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SOIL SURVEY OF RUNNELS COUNTY, TEXAS

BY C. C. WIEDENFELD, L. J. BARNHILL, AND CLIFFORD J. NOVOSAD

UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE TEXAS AGRICULTURAL EXPERIMENT STATION

RUNNELS COUNTY is in west-central Texas (fig. 1). It is nearly square in shape. The total area is 1,060 square miles, or 678,400 acres, of which 1,860 acres is water. The population is about 15,000 of which 8,300 is urban. The average annual rainfall is about 22 inches, and the average annual temperature is 65 degrees. The elevation is 1,500 to 2,300 feet above sea level.

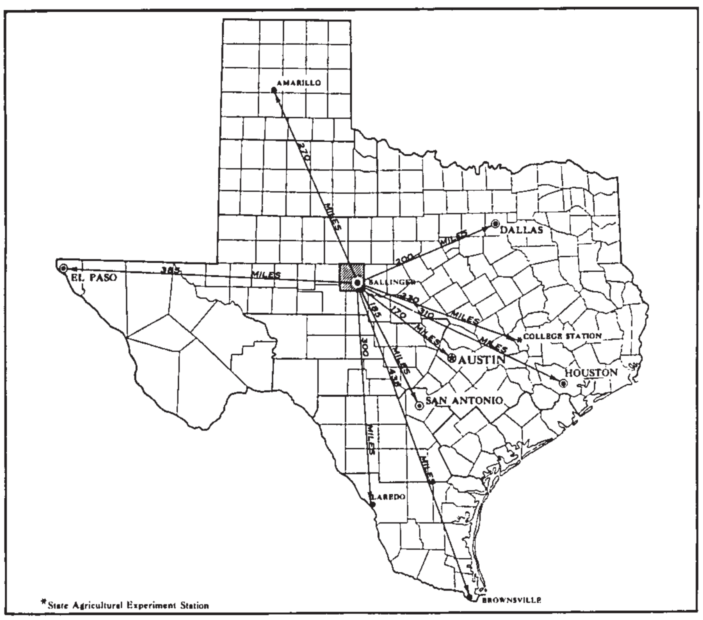

***Figure 1.*—Location of Runnels County in Texas.**

Runnels County is one of the leading counties of Texas in the production of grain sorghum, cotton, sheep, and petroleum. About 373,600 acres is rangeland, 279,900 acres is dry cropland, and 3,500 acres is irrigated.

Most of the county is nearly level to gently sloping. There are a few very steep limestone hills in the northeastern part. About 40 percent of the county has slopes of less than a 1-foot fall in 100 feet. This nearly level land is the best farmland in the county, and most of it is cultivated. About 33 percent of the county has slopes of a 1- to 3-foot fall in 100 feet. This too, is suitable for cultivation, but erosion control is needed. The other 27 percent, or 185,000 acres, is too steep, too shallow, or too sandy to be suitable for crops.

On about 71 percent of the acreage in this county, the soils developed in plains outwash or very old alluvium, on 17 percent they developed in limestone, on 7 percent in recent stream alluvium, and on 5 percent in red marine clay, sandstone, or conglomerate, or in a mixture of these materials.

On about 65 percent of the acreage, the soils are more than 20 inches deep, on 19 percent they are between 10 and 20 inches deep, and on 16 percent they are less than 10 inches deep.

On about 81 percent of the acreage, the surface layer is loamy, on about 18 percent it is clay or silty clay, and on 1 percent it is sandy.

On about 86 percent of the acreage, the soils are calcareous throughout.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Runnels County, where they are located, and how they can be used. They went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this publication efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, the major horizons of all the soils of one series are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Miles and Mereta, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the natural undisturbed

landscape. Soils of one series can differ somewhat in the texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in the texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Miles fine sandy loam and Miles loamy fine sand are two soil types in the Miles series. The difference in the texture of their surface layers is apparent from their names.

Some soil types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into soil phases. The name of a soil phase indicates a feature that affects management. For example, Miles fine sandy loam, 0 to 1 percent slopes, is one of two phases of Miles fine sandy loam, a soil type that has a slope range of 0 to 3 percent.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this survey was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed or occur in such small individual tracts that it is not practical to show them separately on the map. They show such a mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soils in it, for example, Talpa-Kavett complex.

Another kind of mapping unit is the undifferentiated group, which consists of two or more soils that may occur together without regularity in pattern or relative proportion. The individual tracts of the component soils could be shown separately on the map, but the differences between the soils are so slight that the separation is not important for the objectives of the soil survey. An example is Colorado and Yahola soils.

Most surveys include areas where the soil material is so rocky, so shallow, or so frequently worked by wind and water that it cannot be classified by soil series. Such an area is shown on the map like other mapping units, but it is given a descriptive name, such as Rough stony land, and is called a land type.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field and plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way that it is readily useful to different groups of readers, among them farmers, ranchers, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. The soil scientists set up trial groups based on the yield and practice tables and other data. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others; then they adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this publication shows, in color, the soil associations in Runnels County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, drainage, and other characteristics that affect management.

The seven soil associations in Runnels County are described in the paragraphs that follow.

1. Portales-Potter-Mereta association

Nearly level to undulating, loamy soils that are moderately deep to very shallow over caliche; on outwash plains

This association occupies broad areas on upland in most parts of the county. The gradient is mainly 0 to 8 percent but in places is as much as 20 percent. The total area is about 40 percent of the county.

This association is about 37 percent Portales soils, 23 percent Potter soils, 21 percent Mereta soils, and 19 per-

cent Tobosa, Spur, and Colorado soils. The Portales and Mereta soils are nearly level to gently sloping. Potter soils have stronger slopes and occur along drainageways and on convex knolls. Tobosa soils are along shallow drainageways, and Spur and Colorado soils are on flood plains.

Portales soils have a surface layer of dark grayish-brown to brown, calcareous clay loam about 15 inches thick and a subsoil of calcareous clay loam about 13 inches thick. Below the subsoil is a 10-inch layer of pink clay loam that is about 20 percent lime. The lime has accumulated as powdery masses and weakly cemented concretions. The substratum is reddish-yellow, calcareous clay loam.

Potter soils have a loamy, calcareous surface layer that is about 6 inches thick over deep beds of caliche.

Mereta soils have a surface layer of dark-brown, calcareous clay loam about 9 inches thick. Below the surface layer and extending to a depth of 19 inches is brown, calcareous clay loam. The substratum is a bed of caliche that is strongly cemented in the upper part.

About two-thirds of this association is used as native range. The rest is farmed to cotton, wheat, and grain sorghum. Portales and Mereta soils are fairly well suited to cultivated crops. Potter soils are suited to range.

2. *Rowena-Tobosa association*

Nearly level to gently sloping, deep, loamy and clayey soils mainly on outwash plains

This association is characterized by broad areas on uplands, by upland valleys, and by scattered shallow depressions and intermittent lakes. It makes up about 19 percent of the county.

This association is about 45 percent Rowena soils, 40 percent Tobosa soils, and 15 percent Mereta, Portales, and Lipan soils. Rowena soils are on slopes along drainageways. Tobosa soils are below Rowena soils, in nearly level areas and in shallow drainageways. Mereta and Portales soils are typically in gently sloping areas around intermittent lakes and drainageways, and Lipan soils are in the lowest parts of narrow valleys and at the bottoms of shallow depressions and intermittent lakes.

Rowena soils have a surface layer of dark grayish-brown, calcareous heavy clay loam about 9 inches thick and a subsoil of brown, calcareous heavy clay loam to light clay about 38 inches thick. The substratum is pink clay loam to silty clay loam. The uppermost part of this layer contains a few weakly to strongly cemented lime concretions and many soft, powdery lime masses. The percentage of lime decreases with increasing depth.

Tobosa soils have a surface layer of dark grayish-brown, firm, calcareous clay about 20 inches thick. Below the surface layer and extending to a depth of 50 inches is grayish-brown, very firm, calcareous clay. In most areas the substratum is light brownish-gray to pale-brown clay that contains a few soft lime masses, but in some it is hard limestone.

The soils in this association are well suited to locally grown crops and are fairly well suited to large-scale farming. Most of the acreage is cultivated to grain sorghum, cotton, and wheat.

3. *Spur-Colorado-Miles association*

Nearly level to gently sloping, deep, loamy soils mainly on flood plains but also on outwash plains and old stream terraces

This association occurs near major streams. The largest areas are along the Colorado River and along some of the larger streams in the northern part of the county. The total area is about 13 percent of the county.

This association is about 26 percent Spur soils, 24 percent Colorado soils, 19 percent Miles soils, and 31 percent Yahola, Winters, Olton, and Acuff soils. Colorado and Yahola soils are along streambanks and are flooded frequently. Spur soils are nearly level and are on the higher parts of flood plains. Miles, Winters, Olton, and Acuff soils are on stream terraces or low-lying uplands 5 to 50 feet higher in elevation than the flood plains.

Spur soils have a surface layer of dark-brown, calcareous loam about 18 inches thick. Below the surface layer and extending to a depth of 84 inches is reddish-brown, calcareous loam.

Colorado soils have a surface layer of light reddish-brown, calcareous loam about 16 inches thick. Below the surface layer and extending to a depth of 60 inches is light reddish-brown, stratified loam, clay loam, and fine sandy loam.

Miles soils have a surface layer of brown fine sandy loam about 8 inches thick. Their subsoil is sandy clay loam about 52 inches thick. It is reddish brown in the upper part and yellowish red in the lower part. The substratum is calcareous light sandy clay loam. The upper part contains many lime masses.

Most of this association is farmed to cotton, grain sorghum, and small grain. Spur and Miles soils are well suited to locally grown crops. Colorado soils are flooded frequently and are used mostly for native grass and johnsongrass pasture. Irrigated areas are well suited to alfalfa and bermudagrass. Areas beside streams are well suited to pecan trees.

4. *Olton-Vernon-Rowena association*

Nearly level to gently sloping, deep, loamy soils on outwash plains and gently sloping to steep, shallow, clayey soils on uplands

This association is mostly in the northeastern and southwestern parts of the county. The gradient is 0 to 25 percent. The drainage pattern is complex. The total area is about 6 percent of the county.

This association is about 39 percent Olton soils, 25 percent Vernon soils, and 12 percent Rowena soils. The remaining 24 percent consists of Weymouth, Stamford, Colorado, and Tobosa soils and steep, eroded areas of Badland where red underlying material is exposed. Olton and Rowena soils are nearly level to gently sloping and are predominant in valleys. Vernon, Weymouth, and Stamford soils are more sloping and occur along valley sides and on convex knolls. Tobosa soils are in valleys, and Colorado soils are on flood plains.

Olton soils have a surface layer of dark-brown to dark reddish-gray clay loam about 10 inches thick and a subsoil of reddish-brown, firm, heavy clay loam to light clay about 31 inches thick. The substratum is pink to

reddish-yellow clay loam to silty clay loam that contains many lime pebbles.

Vernon soils have a 6-inch surface layer and subsoil of reddish-brown, very firm, calcareous clay. The subsoil extends to a depth of 18 inches. The substratum is weak-red, compact shaly clay that has evident bedding planes. It extends to a depth of 60 inches.

Rowena soils have a surface layer of dark grayish-brown, calcareous heavy clay loam about 9 inches thick and a subsoil of brown, calcareous heavy clay loam to light clay about 38 inches thick. The substratum is pink clay loam to silty clay loam. The upper part contains a few weakly and strongly cemented lime concretions and many soft powdery lime masses. The percentage of accumulated lime decreases with increasing depth.

Most of this association is well suited to range and is used for this purpose. About half of it is fairly well suited to crops. Soil blowing is a slight hazard in cultivated areas of Olton and Rowena soils, and water erosion is a slight to moderate hazard.

5. Cobb-Winters association

Gently sloping to moderately sloping, moderately deep to deep, loamy soils on uplands and outwash plains

This association is in the northwestern part of the county. The total area is about 2 percent of the county.

This association is about 25 percent Cobb soils, 25 percent Winters soils, and 50 percent Miles, Latom, Vernon, and Potter soils. Cobb soils and the very shallow Latom soils occupy the more sloping, higher areas. The deep Winters and Miles soils are on lower lying areas. The shallow to very shallow Vernon and Potter soils are on breaks and in steep areas.

Cobb soils have a surface layer of reddish-brown, neutral fine sandy loam about 18 inches thick and a subsoil of reddish-brown to yellowish-red, neutral sandy clay loam about 18 inches thick. The underlying material is red and yellow sandstone.

Winters soils have a surface layer of reddish-brown fine sandy loam about 10 inches thick. The upper part of the subsoil is dark reddish-brown to red sandy clay about 40 inches thick. The lower part is light reddish-brown clay loam, is 20 inches thick, and contains soft masses and concretions of lime. The substratum is red, calcareous clay loam.

All of this association is well suited to range and is used for this purpose. About half of it is suited to farming and is well suited to locally grown crops. Controlling soil blowing and water erosion are the main problems in clean-tilled areas.

6. Tarrant-Rough stony land association

Undulating to steep, very shallow, clayey soils and steep, stony areas

This association occurs as two small areas of limestone hills in the northeastern part of the county. The gradient is 2 to more than 60 percent. The total area is about 2 percent of the county.

This association is about 27 percent Tarrant soils, 20 percent Rough stony land, and 53 percent Karnes, Winters, and Kavett soils and areas of rock outcrop. Tarrant and Kavett soils occupy the gently sloping to steep parts of the limestone hills, and Rough stony land and rock outcrop the steeper, more barren parts. Karnes and Winters soils are at the base of the hills.

Tarrant soils have a 4- to 12-inch layer of dark-colored clay over fractured limestone. The clay contains many limestone fragments.

Rough stony land has a thin, patchy covering of soil over limestone and chalky marl.

This association is well suited to range and wildlife habitat. It produces a wide variety of desirable forage for livestock and deer. Most of the acreage is used as range. Some of the deeper, loamy soils at the base of hills are cultivated. Controlling runoff from higher lying areas is a problem.

7. Talpa-Kavett association

Undulating to steep, loamy and clayey soils that are very shallow and shallow over limestone; on uplands

This association is characterized by narrow V-shaped valleys, rolling limestone hills and rounded hilltops, and outcrops of limestone and marl. The landscape has a stairstep or benched appearance because the limestone outcrops have been more resistant to weathering than the marl. This association occurs east of Ballinger. It makes up about 18 percent of the county. It is less wooded than association 6.

This association is about 31 percent Talpa soils, 30 percent Kavett soils, and 39 percent Valera and Tobosa soils, rock outcrops, and unclassified alluvial soils. The very shallow Talpa soils are near limestone outcrops. Kavett soils are farther away from the outcrops than Talpa soils and are deeper over limestone. Valera and Tobosa soils and the unclassified alluvial soils are in narrow valleys and drainageways.

Talpa soils have a surface layer of grayish-brown clay loam that is less than 10 inches thick over caliche-coated limestone. Gravel and stones are common on the surface and throughout the surface layer.

Kavett soils have a surface layer of dark grayish-brown, calcareous silty clay about 8 inches thick. Below this is grayish-brown, calcareous silty clay about 8 inches thick. This layer rests abruptly on caliche-coated limestone.

Most of this association is used as native range and is well suited to this use. About 5 percent of the association consists of arable soils in areas large enough for farming. Most of the deeper soils are in long, narrow or irregular patterns that make the use of current farming methods impractical.

Descriptions of the Soils

This section describes the soil series and mapping units of Runnels County. The approximate acreage and the proportionate extent of each mapping unit are given in table 1.

A general description of each soil series is given, and this is followed by brief descriptions of the mapping units in that series. For full information on any one

mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. Unless otherwise indicated, the colors specified are for dry soil. In the description of each mapping unit are suggestions on management.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of the description of each mapping unit are the capability unit and range site in which the mapping unit has been placed. The page on which each range site is described can be found readily by referring to the "Guide to Mapping Units" at the back of this survey.

Many terms used in the soil descriptions and other sections of the survey are defined in the Glossary.

TABLE 1.—*Approximate acreage and proportionate extent of soils*

Soil	Area	Extent
	Acres	*Percent*
Acuff loam, 0 to 1 percent slopes	18, 030	2. 7
Acuff loam, 1 to 3 percent slopes	7, 080	1. 0
Cobb-Latom complex	1, 200	. 2
Cobb-Winters fine sandy loams, 0 to 1 percent slopes	500	. 1
Cobb-Winters fine sandy loams, 1 to 3 percent slopes	2, 300	. 3
Cobb-Winters fine sandy loams, 3 to 5 percent slopes	710	. 1
Colorado and Yahola soils	23, 180	3. 4
Karnes soils, 3 to 8 percent slopes	2, 970	. 4
Kavett silty clay, 0 to 1 percent slopes	2, 170	. 3
Kavett silty clay, 1 to 3 percent slopes	10, 960	1. 6
Lipan clay	3, 880	. 6
Mereta clay loam, 0 to 1 percent slopes	12, 380	1. 8
Mereta clay loam, 1 to 3 percent slopes	55, 610	8. 2
Miles fine sandy loam, 0 to 1 percent slopes	3, 970	. 6
Miles fine sandy loam, 1 to 3 percent slopes	6, 420	1. 0
Miles loamy fine sand, 0 to 3 percent slopes	2, 060	. 3
Olton clay loam, 0 to 1 percent slopes	26, 600	3. 9
Olton clay loam, 1 to 3 percent slopes	17, 200	2. 6
Portales clay loam, 0 to 1 percent slopes	54, 430	8. 0
Portales clay loam, 1 to 3 percent slopes	58, 300	8. 6
Potter soils	64, 260	9. 5
Rough stony land	2, 810	. 4
Rowena and Tobosa soils, 0 to 1 percent slopes	59, 740	8. 8
Rowena and Tobosa soils, 1 to 3 percent slopes	32, 450	4. 8
Spur loam	21, 300	3. 1
Stamford clay, 0 to 1 percent slopes	1, 530	. 2
Stamford clay, 1 to 3 percent slopes	4, 000	. 6
Talpa-Kavett complex	69, 480	10. 2
Tarrant stony clay, 0 to 8 percent slopes	2, 740	. 4
Tarrant stony clay, 8 to 30 percent slopes	930	. 1
Tivoli fine sand	1, 010	. 2
Tivoli-Brownfield fine sands	3, 000	. 4
Tobosa clay, 0 to 1 percent slopes	52, 560	7. 8
Tobosa clay, 1 to 3 percent slopes	7, 130	1. 1
Valera silty clay, 0 to 1 percent slopes	7, 070	1. 0
Valera silty clay, 1 to 3 percent slopes	12, 240	1. 8
Vernon-Badland complex	13, 690	2. 0
Weymouth clay loam, 1 to 3 percent slopes	3, 160	. 5
Winters fine sandy loam, 0 to 1 percent slopes	1, 370	. 2
Winters fine sandy loam, 1 to 3 percent slopes	1, 970	. 3
Winters fine sandy loam, 1 to 3 percent slopes, eroded	2, 860	. 4
Yahola fine sandy loam	1, 290	. 2
Water	1, 860	. 3
Total	678, 400	100. 0

Acuff Series

The Acuff series consists of deep, nearly level to gently sloping soils along streams. These soils are noncalcareous to a depth of about 24 inches but have prominent accumulations of calcium carbonate below this depth. They developed in plains outwash or in old stream alluvium.

In a typical profile the surface layer is dark-brown loam about 12 inches thick. The subsoil is reddish-brown sandy clay loam. It extends to a depth of about 38 inches. Below this is an 18-inch layer of pink sandy clay loam that is about 50 percent lime. The lime has accumulated as concretions and soft masses.

Acuff soils have moderate permeability and a moderate to high capacity for holding water and plant nutrients.

A typical profile of Acuff loam, 0 to 1 percent slopes, is 100 feet east of U.S. Highway 83 from a point 2 miles south of Winters on that highway.

Ap—0 to 12 inches, dark-brown (7.5YR 4/3) loam, dark brown (7.5YR 3/2) when moist; weak, granular and subangular blocky structure; friable when moist; slightly hard when dry; thin surface crust; noncalcareous; moderately alkaline; gradual boundary.

B21t—12 to 24 inches, reddish-brown (5YR 4/3), heavy sandy clay loam, dark reddish brown (5YR 3/3) when moist; moderate, medium, prismatic and subangular blocky structure; firm when moist, hard when dry; many fine pores; worm casts common; noncalcareous; moderately alkaline; gradual boundary.

B22t—24 to 38 inches, reddish-brown (5YR 5/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; fine, prismatic and moderate, medium, subangular blocky structure; firm when moist, hard when dry; few fine pores; roots penetrate peds; calcareous; abrupt boundary.

C1ca—38 to 56 inches, pink (5YR 7/4) sandy clay loam, yellowish red (5YR 5/6) when moist; firm when moist, hard when dry; about 50 percent concretions and soft masses of calcium carbonate; calcareous; clear boundary.

C2—56 to 60 inches +, light reddish-brown (5YR 6/4) sandy clay loam, yellowish red (5YR 5/6) when moist; less calcium carbonate than in C1ca horizon.

The texture of the A horizon ranges from loam to sandy clay loam, and the thickness from 10 to about 14 inches. In dry soil the color ranges from dark reddish gray to dark brown in hue of 7.5YR to 5YR, value of 4 or 5, and chroma of 2 or 3. In moist soil the value is less than 3.5.

The texture of the B2t horizon ranges from heavy sandy clay loam to light sandy clay loam. In dry soil the color ranges from red to dark reddish brown and dark brown in hue of 2.5YR to 7.5YR.

The thickness of the solum ranges from 30 to 50 inches. The thickness of the C1ca horizon ranges from 6 to 24 inches. The percentage of visible calcium carbonate in this layer is 5 to 70. The lime has accumulated as soft masses and as concretions ⅛ to 1 inch in diameter.

Waterworn pebbles occur in all parts of the profile but most commonly in the upper part of the C horizon. Some profiles contain thin gravelly strata.

Acuff soils are associated with Miles and Spur soils. They are more clayey in the A horizon than Miles soils. In comparison with Spur soils, they are noncalcareous in the uppermost part of the profile and have a noticeable accumulation of lime in the lower part, whereas Spur soils are calcareous throughout.

Acuff loam, 0 to 1 percent slopes (AcA).—This soil occurs as smooth areas 5 to 50 feet above the flood plain.

Included in mapping were 3- to 6-acre tracts of Olton clay loam and Miles fine sandy loam. These tracts make up about 6 percent of the total acreage of a mapped area.

This soil has the profile described as typical for the series. The depth to the layer of accumulated lime ranges from about 30 to 50 inches.

This soil is well suited to crops, and most of the acreage is cultivated. Conserving moisture, preserving tilth, and maintaining productivity are the main considerations. Soil blowing is a slight to moderate hazard in cultivated areas. The cropping system should include sorghums, small grain, and other crops that leave large amounts of stubble. Terraces are not needed for erosion control, but they help in conserving water. The response to fertilization is good. (Capability unit IIce-5; Deep Hardland range site)

Acuff loam, 1 to 3 percent slopes (AcB).—This soil occurs as smooth to convex areas 5 to 50 feet above the flood plain. Included in mapping were 3- to 6-acre tracts of Olton clay loam and Miles fine sandy loam and ½-acre to 2-acre tracts of a limy, more shallow soil. These tracts make up about 8 percent of the total acreage of a mapped area.

The surface layer and subsoil of this Acuff soil are thinner than those described as typical for the series, and there are a few rills and shallow gullies. The depth to the layer of accumulated lime is commonly about 32 inches but ranges from 30 to 42 inches.

This soil is well suited to locally grown crops, and most of the acreage is cultivated. Water erosion is a moderate hazard in clean-tilled areas. Soil blowing is a slight hazard. Reducing the amount of runoff, preserving tilth, and maintaining productivity are the main considerations. Using terraces and contour cultivation and growing grain sorghum or other crops that leave large amounts of stubble help in controlling erosion. Keeping stubble on or near the surface improves tilth and fertility and retards erosion. The response to fertilization is good. (Capability unit IIe-2; Deep Hardland range site)

Badland

Badland consists of steep, eroded, barren land that shows little evidence of soil development. Red marine clay is exposed at the surface. The slope is typically 8 to 20 percent. There are many broad gullies 1 foot to 12 feet deep (see figure 14, page 29). The sides of the gullies are steep and concave. Some are nearly vertical. On the surface in most areas are rounded quartzite pebbles that range from a few to many in number and from ¼ inch to about 3 inches in diameter.

Badland has no value as farmland. It is not suitable for cultivation, and it has such sparse vegetation that it is not suitable for range.

The areas of Badland in this county are mapped with Vernon soils. The mapped areas are described under the heading "Vernon Series."

Brownfield Series

The Brownfield series consists of deep, noncalcareous, loose, sandy soils that formed in sandy material, apparently alluvium from the Colorado River. In most places this material has been reworked by wind. The surface is duny.

In a typical profile the surface layer is light-brown fine sand about 24 inches thick. The subsoil is red and yellowish-red sandy clay loam. It extends to a depth of more than 70 inches.

In this county Brownfield soils are mapped with Tivoli soils. The mapped areas are described under the heading "Tivoli Series."

A typical profile of a Brownfield fine sand is 100 feet east of a county road at a point 0.9 mile west and southwest from its intersection with U.S. Highway 67. This intersection is 2.5 miles south of Ballinger.

A1—0 to 24 inches, light-brown (7.5YR 6/4) fine sand, brown (7.5YR 4/4) when moist; structureless; very friable when moist, loose when dry; neutral; gradual boundary.

B2t—24 to 55 inches, red (2.5YR 5/6) sandy clay loam, red (2.5YR 4/6) when moist; moderate, very coarse, prismatic and moderate, medium, subangular blocky structure; firm when moist, very hard when dry; slightly acid; gradual boundary.

B3t—55 to 70 inches +, yellowish-red (5YR 5/6) light sandy clay loam, yellowish red (5YR 4/6) when moist; firm when moist, very hard when dry; slightly acid.

The thickness of the A horizon ranges from 20 to 40 inches. In dry soil the color of this horizon ranges from light brown to yellowish brown in hue of 7.5YR to 10YR, value of 5 or 6, and chroma of 4 to 6.

In dry soil the color of the B2t horizon ranges from dark red to light red in hue of 10YR to 2.5YR, value of 3 to 6, and chroma of 4 to 8. The reaction ranges from slightly acid to mildly alkaline.

The depth to the B3t horizon ranges from 50 to about 72 inches. The texture ranges from light sandy clay loam to fine sandy loam.

Brownfield soils are near Tivoli and Miles soils. They have a B horizon, which Tivoli soils lack. They have a more sandy, thicker, lighter colored A horizon than Miles and Winters soils.

Cobb Series

The Cobb series consists of nearly level to sloping soils that are less than 48 inches deep over sandstone.

In a typical profile the surface layer is reddish-brown fine sandy loam about 18 inches thick. The subsoil is reddish-brown to yellowish-red sandy clay loam about 18 inches thick. Below this is weathered, weakly and strongly cemented, noncalcareous, red and yellow sandstone.

A typical profile of a Cobb fine sandy loam is 100 feet north of a point located 4.1 miles east of the county line marker on U.S. Highway 277.

A11—0 to 12 inches, reddish-brown (5YR 5/3) fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, subangular blocky structure; very friable when moist, soft when dry; a few waterworn pebbles ⅛ to ½ inch in diameter; neutral; gradual boundary.

A12—12 to 18 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) when moist; weak, subangular blocky structure; very friable when moist, slightly hard when dry; waterworn pebbles ⅛ to ½ inch in diameter are common; neutral; clear, smooth boundary.

B21t—18 to 24 inches, reddish-brown (5YR 5/5) light sandy clay loam, reddish brown (5YR 4/5) when moist; weak, prismatic and weak, subangular blocky structure; friable when moist, very hard when dry; a few waterworn pebbles ⅛ to ½ inch in diameter; neutral; gradual boundary.

B22t—24 to 36 inches, yellowish-red (5YR 5/6) sandy clay loam, yellowish red (5YR 4/6) when moist; weak, prismatic structure that breaks to moderate, medium subangular blocky; few clay films on ped surfaces; friable when moist, very hard when dry; a few waterworn pebbles 1/8 to 1/2 inch in diameter; neutral; abrupt boundary.

R—36 to 44 inches +, weathered, weakly and strongly cemented, red and yellow sandstone.

The thickness of the A horizon ranges from 4 to 20 inches. In dry soil the hue is 5YR to 7.5YR, the value 4 or 5, and the chroma 3 or 4.

The thickness of the Bt horizon ranges from 11 to 40 inches but is dominantly less than 29 inches. In dry soil the hue is 2.5YR to 5YR, the value 4 or 5, and the chroma 4 to 6.

In about 50 percent of the profiles observed, there is a layer of accumulated calcium carbonate up to 6 inches thick. In some this layer is calcareous but contains no visible calcium carbonate. In others it is 50 percent concretions and soft masses of calcium carbonate.

The depth to the R horizon ranges from 20 to 48 inches. Most commonly the R horizon is weathered, red or yellow, non-calcareous, fine-grained sandstone. In places it is weathered conglomerate, red marine clay, or siltstone. Most of this material is noncalcareous. In spots where the soil overlies conglomerate, the profile is 2 to 40 percent waterworn pebbles.

Cobb soils are deeper over sandstone than the nearby Latom soils, but they are shallower than Miles soils. They have a sandier, more friable Bt horizon than the nearby Winters soils.

Cobb-Latom complex (Cl).—This complex occupies low ridges and areas adjacent to ridges in the northwestern part of the county. Slopes range from 1 to 8 percent. This complex is about 55 percent Cobb soils and 20 percent Latom soils. Included in mapping were spots of Potter soils and of Winters fine sandy loam, outcrops of sandstone and conglomerate, exposures of marine clays, areas of soils that are similar to Cobb soils except for a surface layer of loamy fine sand, and areas of soils like Cobb soils but only 12 to 20 inches thick over sandstone.

Cobb soils are predominantly gently sloping, but the pockets between sandstone outcrops have stronger slopes. Latom soils occupy ridgetops and steeper parts that are closely associated with sandstone outcrops.

Cobb soils have a surface layer of reddish-brown, noncalcareous fine sandy loam about 10 to 15 inches thick and a subsoil of reddish-brown, noncalcareous sandy clay loam. Ordinarily the underlying material is calcareous to noncalcareous, weakly to strongly cemented sandstone. In places it is weakly to strongly cemented conglomerate.

Latom soils have a surface layer of calcareous fine sandy loam about 8 inches thick. This layer is underlain by strongly cemented, noncalcareous sandstone or conglomerate. The rocks have caliche coatings in the crevices.

Cobb soils have a moderate water-intake rate, medium runoff in sloping areas, and a moderate available water capacity. The risk of water erosion is slight to moderate, and the risk of soil blowing is moderate. Latom soils take in water rapidly but have a low available water capacity. This low capacity and the strong slopes allow much runoff. The risk of water erosion is serious if the soils are overgrazed. Fertility is moderate.

If these soils are to be used as cropland, a cropping system that supplies large amounts of organic matter and litter is needed for control of soil blowing and water erosion. Sorghum and small grain are examples of suitable crops. Tillage should be on the contour. Terraces are needed. In part of the acreage the soils are shallow over sandstone, are not suitable for terracing, and should be in permanent pasture grasses.

This complex is used as range. It produces a wide variety of vegetation. It makes good wildlife habitat because the vegetation includes oaks and other woody plants that provide cover, browse, and mast. (Capability unit IVe-4; Cobb soils in Sandy Loam range site; Latom soils in Sandstone Hills range site)

Cobb-Winters fine sandy loams, 0 to 1 percent slopes (CwA).—This complex occurs as areas about 150 acres in size, in the northwestern part of the county. It is made up of about equal parts of Cobb and Winters soils. These soils are underlain by sandstone, red marine clay and clay loam, and conglomerate. Those underlain by conglomerate contain some resistant quartzitic pebbles. The surface is smooth. Soils similar to Cobb soils except for a surface layer of loamy fine sand make up about 5 percent of each mapped area, and soils that are in small valleys and have a thicker surface layer because of the accumulation of sediments blown or washed from higher lying areas make up another 5 percent. Also included in mapping were a few widely scattered small outcrops of sandstone.

Cobb soils have a reddish-brown, noncalcareous surface layer about 12 to 18 inches thick and a subsoil of reddish, noncalcareous sandy clay loam that extends to a depth of about 36 to 48 inches. The underlying material is weakly cemented sandstone.

Winters soils have a reddish-brown, noncalcareous surface layer about 10 inches thick and a subsoil of reddish, noncalcareous sandy clay that extends to a depth of about 50 inches. The underlying material is reddish, calcareous clay loam that has an accumulation of lime in the uppermost part.

Cobb soils have a moderate water-intake rate and a moderate to high capacity for holding water and plant nutrients. Winters soils have a moderately slow water-intake rate and a moderate to high capacity for holding water and plant nutrients. Both have slow runoff. The risk of water erosion is slight, and the risk of soil blowing is moderate.

These soils are well suited to cultivation, and about half the acreage is cultivated. Large amounts of organic matter and stubble are needed on the surface to control soil blowing. Sorghum and small grain are examples of suitable crops. The response to fertilization is good.

All of this complex is rangeland. It produces a wide variety of vegetation. It makes good wildlife habitat because the vegetation includes oaks and other woody plants that provide cover, browse, and mast. (Capability unit IIIe-4; Sandy Loam range site)

Cobb-Winters fine sandy loams, 1 to 3 percent slopes (CwB).—This complex is on low rounded hills in the northwestern part of the county. It is made up of about equal parts of Cobb and Winters soils. Slopes are convex. Soils similar to Cobb soils except for a surface layer of loamy fine sand make up about 10 percent of each mapped area, Latom soils about 2 percent, and widely scattered sandstone outcrops less than 1 percent.

Cobb soils have a noncalcareous surface layer about 6 to 10 inches thick and a subsoil of reddish, noncalcareous sandy clay loam that extends to a depth of about 30 to 36 inches.

The Winters soils in this complex differ from those in the complexes previously described, mainly in having a 6- to 8-inch surface layer.

These soils have medium runoff. The risk of water erosion is moderate. The risk of soil blowing is moderate.

These soils are well suited to cultivation, and about half the acreage is cultivated. Large amounts of organic matter and stubble on the surface are needed to control soil blowing. Sorghum and small grain are examples of suitable crops. In terracing and leveling, the depth of cuts and fills is limited because of the difference in clay content of the surface layer and subsoil. Areas in which the subsoil is exposed have poor tilth and low fertility. Without terraces, more stubble is needed to slow down runoff. The response to fertilization is good.

This complex is used as range. It produces a wide variety of vegetation. It makes good wildlife habitat because the vegetation includes oaks and other woody plants that supply cover, browse, and mast. (Capability unit IIIe-4; Sandy Loam range site)

Cobb-Winters fine sandy loams, 3 to 5 percent slopes (CwC).—This complex is in the northwestern part of the county, mostly on low rounded hills and ridges. It is made up dominantly of Cobb soils. Slopes are convex. Each mapped area is about 10 percent Cobb loamy fine sand, about 1 percent Latom soils, and about 1 percent outcrops of sandstone and conglomerate.

Cobb soils have a noncalcareous surface layer about 4 to 6 inches thick and a subsoil of reddish, noncalcareous sandy clay loam that extends to a depth of about 30 inches. The underlying material is weakly cemented sandstone. Winters soils have a 4- to 8-inch surface layer.

These soils have moderate permeability and a moderate available water capacity. The risk of soil blowing is moderate, and the risk of water erosion is moderate. Fertility is moderate.

If these soils are to be used as cropland, a cropping system that supplies large amounts of organic matter and litter is needed for control of soil blowing and water erosion. Sorghum and small grain are examples of suitable crops. Tillage should be on the contour. Terraces are needed. In part of the acreage the soils are shallow over sandstone, are not suitable for terracing, and should be in permanent pasture.

This complex is used as range. It produces a wide variety of vegetation. It makes good wildlife habitat because the vegetation includes oaks and other woody plants that provide cover, browse, and mast. (Capability unit IVe-4; Sandy Loam range site)

Colorado Series

The Colorado series consists of deep, calcareous loams, silt loams, and clay loams that developed in recent alluvium on flood plains. These soils occur along all of the major streams in this county. They are subject to frequent flooding and deposition of fresh sediments.

In a typical profile the top layer is light reddish-brown loam about 16 inches thick. The next layer is light reddish-brown, stratified loam, clay loam, and fine sandy loam. It extends to a depth of more than 60 inches.

***Figure 2.*—Profile of Colorado loam. Roots extend to a depth of about 5 feet.**

These soils have a very deep root zone (fig. 2), moderate permeability, and a high capacity for holding water and plant nutrients.

A typical profile of a Colorado loam is 500 feet east of U.S. Highway 83 and 3,400 feet southeast of its intersection with U.S. Highway 67 in Ballinger.

C1—0 to 16 inches, light reddish-brown (5YR 6/3) loam, reddish brown (5YR 4/3) when moist, structureless; hard when dry, friable when moist; surface crust ¼ inch thick; roots are abundant; earthworm casts are few to common; calcareous.

C2—16 to 60 inches +, light reddish-brown (5YR 6/3) stratified loam, clay loam, and fine sandy loam, reddish brown (5YR 4/3) when moist; structureless; hard when dry, friable when moist; few earthworm casts; very thin, slightly darker colored layers of clay loam and fine sandy loam; evidence of recent stratification; bedding planes evident; calcareous.

The profile ranges from loam or silt loam to clay loam in texture and is 18 to 35 percent clay and more than 15 percent coarser than very fine sand. Some profiles are as much as 15 percent gravel. The degree of stratification varies. In dry soil the color of the C1 horizon ranges from light reddish brown through brown and grayish brown to dark brown in hue of 2.5YR through 10YR. In some areas the C1 horizon, when moist, has a color value of less than 3.5. In these areas this layer is less than 10 inches thick. Thin layers below a depth of 15 inches are darker colored than the surface layer. Parts of any layer at a depth between 10 and 40 inches may show

evidence of structural development, but not to such a degree that all bedding planes are destroyed.

Colorado soils are less sandy than Yahola soils. They are lighter colored and more stratified than Spur soils.

Colorado and Yahola soils (Cy).—This unit is 80 percent Colorado loam and 20 percent Yahola fine sandy loam. These soils occur as long narrow strips adjacent to all the major streams in the county. They are most common along the Colorado River (fig. 3). Slopes are dominantly less than 1 percent but are more than 1 percent along streambanks. Typically, Yahola soils are closer to the stream channel and are a few inches to a few feet higher than Colorado soils. Streambanks are short and very steep. Some areas have several secondary flood channels, and there are a few small, steepsided gullies where runoff from higher lying soils crosses the shorter, steeper parts of this unit. Included in mapping were the channels of small intermittent streams and small areas of higher lying Spur soils.

Colorado soils are light reddish brown and calcareous. Yahola soils are described under the heading "Yahola Series." Bedding planes and stratification are evident in both soils, and there is continual evidence of sedimentation and erosion from floodwater.

These soils vary, but generally they are high in natural fertility and have a very deep root zone. The available water capacity is high, and the water-intake rate is moderate. The risk of erosion is moderate in areas bare of vegetation. Flooding occurs once in 1 to 5 years, and each flood lasts less than 2 days.

These soils are not suited to cultivated crops because of the steep slopes, the frequent damaging floods, and the resulting scouring and sedimentation. Because of their nearness to streams, however, and the additional moisture they receive during floods, they are suited to trees, including pecan trees, and they are highly productive of perennial pasture grasses. The cultivation needed to establish grasses and trees is generally possible. Also, many areas can be improved to attract wildlife because they occur as scattered, fairly narrow strips within cultivated tracts. If these areas were protected from overgrazing by livestock, the wide variety of trees, shrubs, forbs, and grasses would provide nesting sites, dens, food, and cover.

Only a few small acreages of these soils are cultivated. The rest is pasture. The vegetation consists mainly of bermudagrass, buffalograss, johnsongrass, and rescuegrass and elm, willow, pecan, and hackberry trees. (Capability unit Vw-1; Loamy Bottomland range site)

Figure 3.—Colorado and Yahola soils along the Colorado River.

Karnes Series

The Karnes series consists of gently sloping to strongly sloping, deep, brown, calcareous, loamy soils. These soils developed in slope alluvium washed from limestone and sandstone formations exposed on hillsides.

In a typical profile the surface layer is brown fine sandy loam about 12 inches thick. The subsoil is very pale brown sandy clay loam that contains many threads of calcium carbonate. This layer extends to a depth of 42 inches. Below this is an 8-inch layer of very pale brown sandy clay loam that is up to 50 percent lime. The lime has accumulated as soft masses and weakly to strongly cemented concretions. Below a depth of 50 inches is pale-brown sandy clay loam.

These soils have moderate permeability, a moderate water-intake rate, and a moderate available water capacity.

A typical profile of a Karnes fine sandy loam is 100 feet east of farm road 382 and 21.9 miles northeast of Ballinger on that road.

A1—0 to 12 inches, brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) when moist; weak, very fine, subangular blocky structure; very friable when moist, soft when dry; calcareous; moderately alkaline; clear boundary.

B2ca—12 to 42 inches, very pale brown (10YR 7/4) sandy clay loam, yellowish brown (10YR 5/4) when moist; weak, fine, subangular blocky and weak, coarse, prismatic structure; friable when moist, hard when dry; many threads of calcium carbonate; calcareous; moderately alkaline; gradual boundary.

C1ca—42 to 50 inches, very pale brown (10YR 7/3) sandy clay loam, light yellowish brown (10YR 6/4) when moist; weak, subangular blocky structure; friable when moist; hard when dry; a few soft calcium carbonate masses and weakly to strongly cemented concretions ⅛ to ⅜ inch in diameter; calcareous; moderately alkaline; gradual boundary.

C2—50 to 60 inches +, pale-brown (10YR 6/3) sandy clay loam, brown (10YR 5/3) when moist; a few soft masses of calcium carbonate.

The thickness of the A horizon ranges from 4 to 16 inches. In dry soil the color ranges from grayish brown to dark yellowish brown in hue of 10YR, value of 4 or 5, and chroma of 2 to 4. In some areas, this horizon, when moist, has a color value of less than 3.5. In these areas the surface layer is less than 10 inches thick. The texture ranges from fine sandy loam to sandy clay loam.

The thickness of the B horizon ranges from 16 to 50 inches. In dry soil the color ranges from very pale brown to light brownish gray to dark reddish brown in hue of 10YR to 5YR. The texture ranges from sandy clay loam to loam. The clay content is 18 to 22 percent.

The content of visible calcium carbonate in the C1ca horizon ranges from almost nothing to about 50 percent; it is slightly higher in this horizon than in the C2 horizon. Most of the profiles observed contain calcium carbonate concretions ⅛ to 1 inch in diameter.

Karnes soils are less clayey in the B horizon than Winters soils. They are calcareous throughout, whereas Winters soils are noncalcareous in the upper part.

Karnes soils, 3 to 8 percent slopes (KaC).—These are deep soils at or near the base of steep limestone hills. They occur only in the northeastern part of the county. The slope is as much as 10 percent in places but is dominantly about 6 percent.

Included in mapping were tracts of shallow soils that are stony or gravelly in places and tracts where the subsoil is clay loam or sandy clay. Each of these inclusions makes up about 5 percent of the total acreage. Also included in the areas mapped were spots where the surface layer is noncalcareous. These spots make up about 15 percent of the total acreage.

About a fourth of the acreage was once used as cropland and is now severely eroded. In some spots these soils have nearly all of their original surface layer. In other spots nearly all of the original surface layer has been removed and there are gullies 1 to 3 feet deep every 100 to 600 feet.

Natural fertility is high. The risk of water erosion is severe, and the risk of soil blowing is moderate. Much of the acreage previously cultivated is now gullied and is used as range. In unplowed areas the vegetation is typically a combination of oak and cedar trees, mid and short grasses, and forbs. Maintaining a good vegetative cover is the best means of controlling runoff, reducing the risk of erosion, and conserving moisture. (Capability unit VIe-5; Sandy Loam range site)

Kavett Series

The Kavett series consists of nearly level to gently sloping, moderately fine textured to fine textured, calcareous soils that are shallow over limestone.

In a typical profile the surface layer is dark grayish-brown silty clay about 8 inches thick. The subsoil is grayish-brown silty clay about 8 inches thick. Below a depth of 16 inches is caliche-coated limestone.

These soils have moderate permeability and a moderate to low available water capacity.

A typical profile of Kavett silty clay, 0 to 1 percent slopes, is 200 feet south of the pump station road and 17.7 miles southeast of Ballinger on that road.

A1—0 to 8 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak to moderate, very fine, subangular blocky and granular structure; firm when moist; very hard when dry; many fine roots; a few limestone fragments ⅛ to ½ inch in diameter; calcareous; moderately alkaline; clear boundary.

B2—8 to 16 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) when moist; moderate, fine, subangular blocky structure; firm when moist, very hard when dry; many fine roots; a few caliche-coated limestone fragments ⅛ to ½ inch in diameter; calcareous; moderately alkaline; abrupt boundary.

Rca—16 inches +, limestone bedrock; strongly cemented caliche coating about 1 inch thick; most cracks sealed with calcium carbonate.

The texture of the A horizon ranges from silty clay to heavy clay loam, and the thickness from 6 to 16 inches. In dry soil the hue is 10YR, the value 3 to 5, and the chroma 2 or 3. Limestone and cemented caliche fragments that range in size from pebbles to cobblestones are few to common but make up less than 50 percent of the soil mass.

The texture of the B2 horizon ranges from silty clay to heavy clay loam, and the thickness from 4 to 14 inches. In dry soil the color ranges from grayish brown to dark grayish brown in hue of 10YR to 2.5Y. Some profiles have flattened caliche plates 2 to 8 inches in diameter in the lowermost 4 inches, just above the limestone. The depth to the Rca horizon ranges from 12 to 20 inches.

Kavett soils are shallower over limestone than Valera soils and deeper over limestone than Tarrant and Talpa soils. They are more clayey than Mereta soils and do not have the strongly cemented caliche C1 horizon that is typical of those soils.

Kavett silty clay, 0 to 1 percent slopes (KvA).—This soil is in the eastern part of the county. It occurs as areas generally less than 60 acres in size, on divides between small drainageways and on valley floors. It has the profile described as typical for the series. Included in mapping were spots of Valera silty clay and Talpa clay loam, both of which make up about 5 percent of each mapped area.

This Kavett soil is suited to cultivation, but droughtiness resulting from the low rainfall, the shallow root zone, and the moderate water-holding capacity restricts the selection of crops and limits yields. Increasing the available water capacity and preserving or improving tilth are the main considerations. Large amounts of organic matter are needed. Sorghum, small grain, and other high-residue crops should be grown most of the time. The risk of erosion is only slight. Only about half the acreage is cultivated. The rest is used as range. (Capability unit IVs–2; Shallow range site)

Kavett silty clay, 1 to 3 percent slopes (KvB).—This soil occurs as areas about 50 acres in size on hillsides and hilltops or divides in the limestone areas in the eastern part of the county. Included in mapping were spots of Valera silty clay, which make up about 1 percent of each mapped area, and spots of Talpa clay loam, which make up about 5 percent of each mapped area.

This Kavett soil is slightly lighter colored, slightly less clayey, and about 1 or 2 inches shallower over limestone than the one described as typical for the series.

Droughtiness is a limitation. Shallowness restricts the root zone and limits the amount of moisture available for plants. Runoff is medium. The erosion risks are moderate. Keeping the surface layer in good tilth is difficult. Large amounts of organic matter are needed to preserve tilth, slow down runoff, and increase the amount of water that goes into the soil. Sorghum, small grain, and other crops that produce a large amount of stubble should be grown frequently.

The acreage is about equally divided between rangeland and cropland. The crop most commonly grown is small grain, for grain and grazing. (Capability unit IVe–12; Shallow range site)

Latom Series

The Latom series consists of gently sloping to steep, moderately coarse textured soils that are less than 20 inches deep over sandstone.

In a typical profile the surface layer is brown fine sandy loam about 8 inches thick. Below this is pale-yellow, strongly cemented, noncalcareous sandstone.

In this county Latom soils are mapped with Cobb soils. The mapped areas are described under the heading "Cobb Series."

A typical profile of Latom fine sandy loam is 400 yards north of U.S. Highway 277 and 0.3 mile east of the county line marker on U.S. Highway 277.

A1—0 to 8 inches, brown (7.5YR 5/3) fine sandy loam, dark brown (7.5YR 4/3) when moist; weak, subangular blocky structure; very friable when moist, soft when dry; few sandstone fragments; calcareous; moderately alkaline; abrupt boundary.

R—8 to 12 inches, pale-yellow (2.5Y 8/4), strongly cemented, noncalcareous sandstone with caliche coatings in cracks and between stones. Very difficult to cut with a spade below a depth of 12 inches.

The texture of the A horizon ranges from fine sandy loam to gravelly sandy loam. The thickness ranges from 4 to 20 inches but is dominantly 5 to 12 inches. In dry soil the hue is 5YR to 10YR, the value 4 or 5, and the chroma 3 or 4. There are sandstone fragments on the surface and throughout the profile, but they vary in abundance. There are also few to common limestone fragments and waterworn pebbles in some profiles.

Latom soils are near Cobb, Winters, Vernon, Olton, and, in some places, Potter soils. They are shallower than Cobb, Winters, and Olton soils. They are more sandy than Vernon and Potter soils and overlie sandstone instead of red marine clay or caliche.

Lipan Series

The Lipan series consists of deep, calcareous, nearly level clays in playas. These soils developed in clayey plains outwash.

In a typical profile the surface layer is gray clay about 18 inches thick. The next layer is light brownish-gray clay about 30 inches thick. Below a depth of 48 inches is pale-brown clay that is about 5 percent lime. The lime has accumulated as soft masses and weakly cemented concretions.

The playas are intermittently ponded. Water movement through the soil is slow, and the available water capacity is high.

A typical profile of Lipan clay is 0.1 mile south of a county road from a point 0.8 mile east of Miles.

Ap—0 to 6 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; weak blocky structure; surface mulch of very hard, very fine aggregates in uppermost 2 inches; very hard when dry, very firm when moist, very sticky and plastic when wet; a few rounded siliceous pebbles about ¼ inch in diameter; calcareous; moderately alkaline; abrupt, smooth boundary.

A1—6 to 18 inches, gray (10YR 5/1) clay, dark gray (10YR 4/1) when moist; moderate, very fine and fine, angular blocky structure; extremely hard when dry; very firm when moist, very sticky and very plastic when wet; few subrounded siliceous pebbles about ¼ inch in diameter; calcareous; moderately alkaline; gradual boundary.

AC—18 to 48 inches, light brownish-gray (10YR 6/2) clay, dark grayish brown (10YR 4/2) when moist; moderate, medium, angular blocky structure and wedge-shaped peds or parallelepipeds ¼ to ½ inch long; extremely hard when dry, very firm when moist, very sticky and plastic when wet; few intersecting slickensides begin at a depth of about 24 inches and become more strongly expressed with increasing depth; a few subrounded siliceous pebbles; calcareous; lower part less than 1 percent white masses and weakly to strongly cemented concretions of calcium carbonate; moderately alkaline; gradual boundary.

Cca—48 to 62 inches +, pale-brown (10YR 6/3) clay, brown (10YR 5/3) when moist; massive; very hard when dry, very firm when moist, sticky and plastic when wet; about 5 percent soft white masses of calcium carbonate and a few weakly cemented concretions; few siliceous pebbles; calcareous; moderately alkaline.

In about 85 percent of the profiles observed, the A horizon is calcareous, but in some the uppermost 8 inches is noncalcareous. The texture of this horizon ranges from clay to silty clay. The structure is angular blocky and ranges from weak to moderate, and in some profiles parallelepipeds are evident below the Ap horizon. In dry soil the color is gray in hue of 7.5YR through 10YR, value of 4.5 to 6, and chroma of 0.5 to 1.5. In moist soil the color is about one unit lower in value. In

places the A horizon, when moist, has a color value of 3.5 or less. In these places this layer is thinner than 12 inches.

The structure of the AC horizon is weak to moderate, fine to coarse, angular blocky. There are many wedge-shaped peds or parallelepipeds, the axes of which are tilted more than 10 degrees from the horizontal.

The content of calcium carbonate in the Cca horizon ranges from a few powdery masses and weakly cemented concretions to as much as 40 percent of the soil mass.

Lipan soils are associated with Tobosa and Rowena soils. They are lighter colored in the A horizon than Tobosa soils and are more clayey and lighter colored in the A horizon than Rowena soils.

Lipan clay (Lc).—This soil occurs as scattered depressions, 1 to 20 feet lower than the surrounding soils, throughout the outwash plains. It is covered with water during and after periods of heavy rainfall. Most areas are between 5 and 40 acres in size, but some are as large as 200 acres. Most are nearly round; a few occur as long, narrow strips along shallow, poorly defined drainageways. The surface is nearly level or concave. Included in mapping were tracts less than 5 acres in size of Tobosa clay, which make up about 5 percent of each mapped area, and a few spots where the soil is noncalcareous in the uppermost 15 inches.

Nearly all of the acreage is cultivated. Natural fertility is high. Controlling excess water and keeping the surface layer in good tilth are the most important factors in management. The extra water this soil receives from higher lying soils makes it one of the most productive soils in the county during periods of light rainfall. Good crops are also harvested during periods of moderate rainfall. For consistently good crops, however, some means of handling excess water during periods of heavy rainfall is needed; otherwise, planting, cultivation, and harvesting have to be delayed. Generally runoff can be controlled by terracing the adjacent soils. Some areas can be drained through canals, and some by drilling wells or shafts into underground cavities. Concentrating the excess water in pits is possible in some of the lakes. The pond can then be used by livestock and waterfowl and as a source of irrigation water. Growing crops that add at least moderate amounts of organic matter preserves tilth and increases water intake. (Capability unit IIIw-1; Deep Upland range site)

Mereta Series

The Mereta series consists of nearly level to gently sloping, calcareous soils that are shallow over hardened caliche. Slopes are convex.

In a typical profile the surface layer is dark-brown to brown clay loam about 19 inches thick. Next is a 5-inch layer of strongly cemented caliche. Below a depth of 24 inches is pink clay loam that is about 20 percent lime.

These soils have a moderate water-intake rate and a low available water capacity.

A typical profile of Mereta clay loam, 0 to 1 percent slopes, is just south of a county road at a point 0.7 mile east of its intersection with farm road 381. This intersection is 4 miles south of Rowena.

Ap—0 to 5 inches, dark brown (10YR 4/3) clay loam, dark brown (10YR 3/3) when moist; weak subangular blocky structure; firm when moist, hard when dry; a few cemented caliche fragments 1/16 inch to 6 inches across the long axes; calcareous; moderately alkaline; abrupt, smooth boundary.

A11—5 to 9 inches, dark-brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; a few cemented caliche fragments and a few waterworn pebbles 1/16 inch to 2 inches across the long axes; calcareous; moderately alkaline; clear, smooth boundary.

A12—9 to 19 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 3/4) when moist; moderate, fine and very fine, subangular blocky structure; firm when moist, hard when dry; a few earthworm casts, a few cemented caliche fragments, and a few waterworn pebbles 1/16 inch to 2 inches in diameter; calcareous; moderately alkaline; abrupt, wavy boundary.

C1ca—19 to 24 inches, white (10YR 8/2), strongly cemented caliche, somewhat platy; hardest in the uppermost part; few roots in crevices; gradual boundary.

C2ca—24 to 40 inches, pink (7.5YR 7/4) clay loam, strong brown (7.5YR 5/6) when moist; about 20 percent soft masses of calcium carbonate; few roots.

The thickness of the Ap and A11 horizons combined ranges from 5 to 11 inches. The texture ranges from clay loam to silty clay loam. In dry soils the color ranges from brown to very dark grayish brown in hue of 10YR to 7.5YR, value of 3 to 5, and chroma of 2 or 3.

The thickness of the A12 horizon ranges from 5 to 15 inches, and the texture from clay loam to silty clay loam. In dry soil

Figure 4.—**Profile of Mereta clay loam. Roots penetrate through cracks and filled-in animal burrows in hardened caliche.**

Figure 5.—**Cemented caliche near surface of Mereta clay loam, 0 to 1 percent slopes.**

the color ranges from reddish brown through dark reddish brown, brown, and dark brown in hue of 5YR to 10YR, value of 3 to 5, and chroma of 2 to 4. The structure is moderate, medium to very fine, subangular blocky.

The depth to the Cca horizon ranges from 10 to 20 inches. The thickness of the cemented C1ca horizon ranges from 2 to 16 inches. The boundary between the C1ca and the C2ca is gradual or diffuse. Cementation is strongest in the uppermost part of the Cca horizon and becomes weaker with increasing depth. Cracks through which roots (fig. 4) penetrate this cemented material are 1 foot to 3 feet apart.

Mereta soils are near Rowena, Potter, Portales, Tobosa, and Lipan soils. They are deeper than Potter soils, which are less than 10 inches deep over caliche. They are shallower than the rest of the nearby soils and also differ in having a zone of cemented calcium carbonate. They are less clayey than Kavett soils and overlie loamy outwash instead of limestone.

Mereta clay loam, 0 to 1 percent slopes (McA).—This soil is well distributed throughout the outwash plains. It occurs as tracts 5 to 200 acres in size on uplands, typically below Potter soils and above Portales, Rowena, and other deeper soils. Included in mapping were areas of Potter soils, which make up about 10 percent of each mapped area, and spots of Portales clay loam, which make up about 5 percent of each area.

This Mereta soil has the profile described as typical for the series. The zone of accumulated calcium carbonate is at a depth of about 19 inches. The boundary above the zone of cemented caliche is broadly wavy or undulating (fig. 5). Implements used in deep tillage or terrace construction generally cut into the high spots and bring broken fragments to the surface.

About half the acreage is cropland, and the rest rangeland. The erosion hazard is only slight. Droughtiness limits the choice of crops, and shallowness limits the depth of plowing and the depth of cuts in terracing or leveling. Although terraces are not needed for erosion control, they help in conserving water. More rainwater can be absorbed if the surface is left rough and cloddy and covered with stubble (fig. 6). Large amounts of organic matter should be returned to the soil. Drought-resistant crops should be grown. A small grain crop is a good choice because it requires the most moisture in spring, which is the period of heaviest rainfall. Sorghum tends to turn yellow in areas where caliche is near the surface, because of an iron shortage. The range vegetation consists of short grasses and mesquite and many other woody plants. (Capability unit IIIe-6; Shallow range site)

Figure 6.—**Small-grain stubble on rough, cloddy surface of Mereta clay loam, 0 to 1 percent slopes.**

Mereta clay loam, 1 to 3 percent slopes (McB).—This soil is closely associated with Mereta clay loam, 0 to 1 percent slopes. It has a thicker, more strongly cemented caliche layer than that soil. The depth to the zone of lime accumulation is generally about 15 inches but ranges from 10 to 20 inches. Included in mapping were areas of Potter soils and areas of Portales clay loam. Each inclusion makes up about 5 percent of the acreage.

About half the acreage is cropland, and the rest rangeland. Runoff is medium, and the erosion hazard is moderate. Droughtiness limits the choice of crops. Shallowness limits the depth of plowing and the depth of cuts in terracing or leveling. Large amounts of organic matter should be returned to the soil, and drought-resistant crops should be grown. A small grain crop is a good choice because its moisture requirement is greatest in spring, which is the period of heaviest rainfall. Sorghum tends to turn yellow in areas where caliche is near the surface, because of an iron shortage. Tillage should be on the contour. Terraces are needed. Unless terraced, this soil should be in small grain continuously or in permanent pasture. The range vegetation consists of short grasses and mesquite and many other woody plants. (Capability unit IIIe-7; Shallow range site)

Miles Series

The Miles series consists of deep, nearly level to gently sloping, noncalcareous, sandy soils that have a distinct zone of lime accumulation. These soils are on outwash plains or old terraces along major streams. They developed in calcareous, moderately sandy outwash or old alluvium.

In a typical profile the surface layer is brown fine sandy loam about 8 inches thick. The subsoil is reddish-brown to yellowish-red sandy clay loam to a depth of about 60 inches. Below this is a 3-inch layer of pink light sandy clay loam that is about 50 percent lime. Below a depth of 63 inches is reddish-yellow light sandy clay loam.

These soils have a moderate water-intake rate and a low available water capacity.

A typical profile of Miles fine sandy loam, 0 to 1 percent slopes, is 100 feet north of a county road at a point 5.5 miles east of U.S. Highway 83. The intersection of this county road and the highway is 6.3 miles south of Ballinger.

Ap—0 to 8 inches, brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) when moist, dark reddish brown (5YR 3/4) when crushed; weak granular structure;

very friable when moist, slightly hard when dry; a few rounded pebbles 1/10 to 1 inch in diameter; moderately alkaline, but noncalcareous; clear boundary.

B21t—8 to 22 inches, reddish-brown (5YR 4/4) sandy clay loam, dark reddish brown (5YR 3/4) when moist; weak, very coarse, prismatic and medium, subangular blocky structure; firm when moist; very hard when dry; a few worm casts; a few rounded pebbles 1/10 to 1 inch in diameter; neutral; gradual boundary.

B22t—22 to 40 inches, yellowish-red (5YR 4/5) sandy clay loam, yellowish red (5YR 3/5) when moist; weak, medium, subangular blocky structure; firm when moist, very hard when dry; a few worm casts; a few rounded pebbles 1/10 to 1 inch in diameter; neutral; gradual boundary.

B23t—40 to 60 inches, yellowish-red (5YR 5/6) light sandy clay loam, yellowish red (5YR 4/6) when moist; weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; a few threads of calcium carbonate; a few rounded pebbles 1/10 to 1 inch in diameter; calcareous in matrix; moderately alkaline; clear boundary.

B3ca—60 to 63 inches, pink (5YR 7/4) light sandy clay loam, reddish brown (5YR 5/4) when moist; weak, medium, subangular blocky structure; friable when moist, slightly hard when dry; about 50 percent calcium carbonate, one-third of which is weakly to strongly cemented concretions 1/10 to 3/4 inch in diameter; calcareous in matrix; moderately alkaline; clear boundary.

C—63 to 70 inches, reddish-yellow (5YR 6/6) light sandy clay loam, yellowish red (5YR 5/6) when moist; much less calcium carbonate than in B3ca horizon; about 5 percent calcium carbonate concretions; moderately alkaline.

The thickness of the A horizon ranges from 4 to 20 inches. In dry soil the color ranges from reddish brown through brown and yellowish brown in hue of 5YR to 10YR, value of 4 or 5, and chroma of 3 to 6. The texture is fine sandy loam or loamy fine sand but varies according to the number of fine soil particles that are removed through soil blowing and the amount of clayey subsoil material that is mixed with the Ap horizon through deep plowing. The organic-matter content of the A horizon is less than 1 percent.

The thickness of the B horizon ranges from about 30 to 60 inches. In dry soil the color ranges from red through yellowish red and reddish brown in hue of 2.5YR to 5YR, value 4 or 5, and chroma of 4 to 8.

The depth to the B3ca horizon ranges from 50 to about 72 inches. The zone of lime accumulation is prominent. The content of calcium carbonate ranges from 10 to 50 percent. Concretions 1/16 inch to 2 inches in diameter range from a few to as much as 30 percent of the soil mass. The number of concretions decreases with increasing depth.

Miles soils are similar to Brownfield and Cobb soils. They are deeper than Cobb soils, which are less than 48 inches deep over sandstone. They are less sandy and have a thinner, darker colored A horizon than Brownfield soils. Miles soils are also near Olton, Winters, and Acuff soils. They have a slightly lighter colored A horizon and a more friable and less clayey B horizon than Olton and Winters soils. They are lighter colored than Acuff soils.

Miles fine sandy loam, 0 to 1 percent slopes (MfA).—This soil occurs along the larger streams, about 5 to 50 feet above the flood plain. Included in mapping were spots where the soils are calcareous throughout. These spots are near small streams or are downslope from and receive runoff from other calcareous soils. They make up about 5 percent of each mapped area.

This Miles soil has the profile described as typical for the series. Generally the depth to the zone of lime accumulation is nearly 5 feet.

This soil is well suited to all crops commonly grown. It is particularly good for home orchards and gardens. Natural fertility is high, but fertilization is needed because plant nutrients are readily leached from the surface layer. The response to fertilization is good. Most of the acreage is cultivated. Soil blowing is a moderate hazard. Crops that leave large amounts of stubble should be included in the cropping system. Sorghum and small grain are examples of such crops. (Capability unit IIIe-4; Sandy Loam range site)

Miles fine sandy loam, 1 to 3 percent slopes (MfB).—This soil occurs along streams, about 5 to 50 feet above the flood plain. The surface is smooth and convex. Included in mapping and making up about 10 percent of the total acreage were areas of noncalcareous fine sandy loams that are 14 to 24 inches deep over strongly cemented caliche or conglomerate.

This Miles soil is moderately eroded. In many areas it has lost 10 to 30 percent of its original surface layer through soil blowing and water erosion. The thickness of the present surface layer is generally about 7 inches but in spots is only 3 to 5 inches. The depth to calcareous material is generally about 30 inches but ranges from 20 to 60 inches. The depth to the zone of lime accumulation ranges from 50 to 80 inches.

This soil is well suited to all crops commonly grown. It is particularly good for home orchards and gardens. Natural fertility is high, but fertilization is needed because plant nutrients are readily leached from the surface layer. The response to fertilization is good. Most of the acreage is cultivated. Runoff is medium, and soil blowing is a moderate hazard. Terraces are needed. In addition, crops that leave large amounts of stubble and organic matter should be included in the cropping system. Sorghum and small grain are examples of such crops. In terracing and leveling, the depth of cuts and fills must be limited because of the difference in clay content of the surface layer and the subsoil. Areas in which the subsoil is exposed have poor tilth and low fertility. (Capability unit IIIe-4; Sandy Loam range site)

Miles loamy fine sand, 0 to 3 percent slopes (MlB).—This soil occurs on high terraces along all of the major streams. The largest acreage is along the Colorado River. Low dunes along fences and around vegetation are common in most areas. Included in mapping were areas where the subsoil is sandy clay. These areas make up less than 5 percent of the total acreage.

The thickness of the surface layer is typically about 14 inches but ranges from 6 to 20 inches. In a few spots all but 4 to 6 inches of the original surface layer has been removed through soil blowing. The subsoil is sandy clay loam 30 to 60 inches thick. The depth to the zone of lime accumulation is typically about 66 inches but ranges from 50 to about 80 inches.

This soil is well suited to all crops commonly grown. It is particularly good for home orchards and gardens. The response to fertilization is good. Most of the acreage is cultivated. Soil blowing is a severe hazard. In areas where the surface layer is uniform in thickness, it should be stabilized through deep plowing, which would bring subsoil material to the surface. The surface layer is too sandy to be stable in terraces, and mixing of the two layers before terraces are constructed is most

important. Leveling is not desirable. It deepens the loamy fine sand in low places and exposes the sandy clay loam subsoil where cuts are made. Large amounts of residue and organic matter are needed for control of soil blowing. Standing stubble is more effective than litter. Tillage should be on the contour. Terraces are needed. Unless terraced, this soil should be in small grain each year or in permanent pasture grasses. (Capability unit IVe–6; Deep Sand range site)

Olton Series

The Olton series consists of deep, nearly level to gently sloping, noncalcareous, well-drained soils that have a distinct zone of lime accumulation. These soils are widely distributed throughout the county. They developed in reddish, calcareous outwash or old alluvium.

In a typical profile the surface layer is dark-brown to dark reddish-gray clay loam about 10 inches thick. The subsoil is reddish-brown heavy clay loam to light clay. It extends to a depth of about 41 inches. Below this is a 15-inch layer of pink silty clay loam that is about 40 percent lime. Below a depth of 56 inches is reddish-yellow clay loam.

Olton soils have slow to medium runoff, a moderately slow water-intake rate, and a high capacity for holding water and plant nutrients.

A typical profile of Olton clay loam, 0 to 1 percent slopes, is 150 feet west of a county road from a point on the county road 3 miles north and 1.6 miles west of Rowena.

Ap—0 to 5 inches, dark-brown (7.5YR 4/2) clay loam, dark reddish brown (5YR 3/2) when moist; weak subangular blocky and granular structure; firm when moist, hard when dry; a few waterworn pebbles and chert fragments 1/16 inch to 4 inches in diameter; mildly alkaline; abrupt boundary.

A1—5 to 10 inches, dark reddish-gray (5YR 4/2) clay loam, dark reddish brown (5YR 3/2) when moist; weak subangular blocky structure; firm when moist, very hard when dry; few fine tubes and pores; few waterworn pebbles 1/16 to 1/2 inch in diameter; mildly alkaline; clear, smooth boundary.

B21t—10 to 18 inches, reddish-brown (5YR 4/3) heavy clay loam, dark reddish brown (5YR 3/3) when moist; moderate, fine, blocky and subangular block structure; firm when moist, extremely hard when dry; few tubes and pores; few earthworm casts; ped surfaces are slightly darker colored than interiors, and clay films are nearly continuous; neutral; clear, wavy boundary that has a difference of 4 inches between the highs and lows over a distance of 18 inches.

B22t—18 to 41 inches, reddish-brown (5YR 4/4) light clay, dark reddish brown (5YR 3/4) when moist; moderate fine, blocky structure; firm when moist, extremely hard when dry; a few earthworm casts; a few specks of calcium carbonate on ped surfaces; moderately alkaline; gradual boundary.

C1ca—41 to 56 inches, pink (5YR 8/4) silty clay loam, reddish yellow (5YR 6/6) when moist; structureless; firm when moist, very hard when dry; about 40 percent calcium carbonate, the amount of which decreases with increasing depth; 10 percent weakly to strongly cemented calcium carbonate concretions 1/4 to 3/4 inch in diameter; calcareous; moderately alkaline; diffuse, wavy boundary that varies as much as 12 inches between the highs and lows.

C2—56 to 70 inches +, reddish-yellow (5YR 7/6) clay loam, yellowish red (5YR 5/6) when moist; weak subangular blocky structure; firm when moist, very hard when dry; about 5 percent weakly cemented calcium carbonate concretions 1/8 to 1/2 inch in diameter.

The texture of the A horizon ranges from clay loam to silty clay. The thickness ranges from 5 to 15 inches. In dry soil the color ranges from red through dark reddish gray, reddish brown, brown, and dark brown in hue of 2.5YR to 7.5YR, value of 3 or 4, and chroma of 2 to 6.

The thickness of the Bt horizon ranges from 18 to 35 inches. In dry soil the color ranges from red to dark reddish brown and dark brown in hue of 2.5YR to 7.5YR, value of 3 to 5, and chroma of 3 to 6. The upper part of this horizon is noncalcareous, but the lower part, below a depth of 20 inches, is typically calcareous.

The depth to the C1ca horizon ranges from about 30 to 50 inches. The amount of visible calcium carbonate in this horizon ranges from a few concretions and soft lumps to 50 percent of the soil mass. The calcium carbonate equivalent is 15 percent or more. In some profiles this horizon is a bed of waterworn gravel cemented with calcium carbonate.

In about 30 percent of the profiles observed there are few to many waterworn pebbles, ranging in size from 1/8 inch to 2 inches, scattered on the surface and throughout the profile. The pebbles generally increase in number with increasing depth but make up less than 20 percent of any horizon above the C horizon. Under some profiles there is an appreciable amount of material, derived from red marine clay, that contains waterworn siliceous pebbles.

Olton soils are more clayey in the Bt horizon than Miles, Cobb, and Acuff soils. They are redder than Rowena soils and have a Bt horizon, which Rowena soils lack. They differ from Winters soils in having more clay and a larger supply of organic matter in the A horizon.

Olton clay loam, 0 to 1 percent slopes (OcA).—This soil is widely distributed throughout the county, but the largest acreages are in the northern and western parts and along the Colorado River. The areas are 15 to 100 acres in size. Included in mapping were spots of Rowena clay loam and spots where the surface layer is calcareous. Each spot is less than 10 acres in size. Each inclusion makes up about 5 percent of each mapped area.

This Olton soil has the profile described as typical for the series. The surface layer is about 10 inches thick. The subsoil is about 30 inches thick over a layer of lime accumulation.

This soil is well suited to crops, and most of the acreage is cultivated. Sorghum, small grain, or other crops that leave large amounts of residue are important in preserving tilth and in reducing the hazard of soil blowing. Terraces are not needed for erosion control, but they help in conserving water. There is little or no hazard of water erosion and only a slight hazard of soil blowing. (Capability unit IIce–4; Deep Hardland range site)

Olton clay loam, 1 to 3 percent slopes (OcB).—This soil is closely associated with Olton clay loam, 0 to 1 percent slopes. The slope is typically less than 2 percent. Included in mapping were areas of Rowena clay loam, which make up about 5 percent of each mapped area, and spots of an unnamed shallow soil, which make up about 1 percent of each area.

This Olton soil is good for cropland, and most of the acreage is cultivated. The risk of soil blowing is slight, and that of water erosion moderate. Large amounts of organic matter must be returned to the soil for control of runoff. Sorghum, small grain, or some other crop that leaves large amounts of residue should be grown frequently. Tillage should be on the contour. Terraces are needed. Unless ter-

raced, this soil should be in small grain continuously or in permanent pasture grasses. (Capability unit IIIe-2; Deep Hardland range site)

Portales Series

The Portales series consists of nearly level to gently sloping, well-drained, loamy soils that are moderately deep over a layer of accumulated lime. These soils developed in calcareous material on outwash plains.

In a typical profile the surface layer is dark grayish-brown to brown, calcareous clay loam about 15 inches thick. The subsoil is firm, brown, calcareous clay loam. It extends to a depth of 28 inches. Below this is a 10-inch layer of pink clay loam that is 20 percent lime (fig. 7). The lime has accumulated as powdery masses and weakly cemented concretions. Below a depth of about 38 inches is reddish-yellow, calcareous clay loam.

Portales soils have moderate permeability and a high capacity for holding water and plant nutrients.

A typical profile of Portales clay loam, 0 to 1 percent slopes, is 60 yards south of Texas Highway 158 from a point 5.2 miles west of Ballinger on the highway.

Figure 7.—**Profile of Portales clay loam. Lime occurs throughout the profile but is most concentrated at a depth of 28 to 38 inches.**

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak, subangular blocky structure; friable when moist, slightly hard when dry; few waterworn pebbles 1/16 to 1/2 inch in diameter; calcareous; moderately alkaline; abrupt, smooth boundary.

A1—7 to 15 inches, brown (7.5YR 4/2) clay loam, dark brown (7.5YR 3/2) when moist; moderate, fine and very fine, subangular blocky structure; friable when moist, hard when dry; earthworm casts common; waterworn pebbles 1/16 to 1/2 inch in diameter common; calcareous; moderately alkaline; clear, smooth boundary.

B2—15 to 28 inches, brown (7.5YR 5/2) clay loam, brown (7.5YR 4/2) when moist; moderate, fine and very fine, subangular blocky structure; firm when moist, hard when dry; few pebbles 1/16 inch to 2 inches in diameter; earthworm casts common; calcareous; moderately alkaline; clear, smooth boundary.

C1ca—28 to 38 inches, pink (7.5YR 8/4) clay loam, light brown (7.5YR 6/4) when moist; weak, subangular blocky structure; friable when moist, hard when dry; visible calcium carbonate is about 20 percent in the form of powdery masses and weakly cemented concretions; calcareous; moderately alkaline; gradual, wavy boundary.

C2—38 to 60 inches +, reddish-yellow (5YR 7/6) clay loam; yellowish red (5YR 5/6) when moist; structureless; friable when moist, hard when dry; calcareous; moderately alkaline.

The texture of the A horizon ranges from clay loam to silty clay loam. The thickness ranges from 7 to 16 inches. In dry soil the color ranges from dark grayish brown to grayish brown and brown in hue of 7.5YR to 10YR, value of 4 or 5, and chroma of 2 or 3. In moist soil the value is less than 3.5 to a depth of at least 7 inches, or to a depth of at least one-third the depth of the material above the C1ca horizon.

The texture of the B horizon is clay loam or silty clay loam. The thickness ranges from 4 to 20 inches. In dry soil the hue is 5YR to 10YR, the value 5 or 6, and the chroma 2 to 4.

The depth to the C1ca horizon ranges from 20 to 36 inches. The percentage of calcium carbonate is 15 to 60. The percentage of concretions is none to 20, and the size ranges from 1/16 inch to 2 inches. Some profiles have platy caliche nodules 2 to 6 inches in diameter and 1 or 2 inches thick.

Portales soils occur near Potter, Mereta, Rowena, and Lipan soils. They are deeper and have a more friable layer of accumulated lime than Potter and Mereta soils. They are less clayey throughout the profile than Rowena and Lipan soils.

Portales clay loam, 0 to 1 percent slopes (PoA).—This soil occurs as smooth, scattered areas on outwash plains throughout the county. Included in mapping were areas of Rowena clay loam and Mereta clay loam. Each of these soils makes up about 4 percent of a mapped area.

This Portales soil has the profile described as typical for the series. The layer of accumulated lime is 6 to 36 inches thick and is 15 to 60 percent calcium carbonate. In about half the areas, this layer is soft and has a few lime concretions in places. In the rest, this layer is cemented and there is soil material between the plates and in the cracks.

This soil is well suited to crops. Most of the acreage is cultivated. Soil blowing is a moderate hazard (fig. 8) in cultivated areas. Conserving moisture, preserving tilth, and maintaining productivity are the main considerations. The cropping system should include sorghum, small grain, and other crops that leave large amounts of stubble. Ter-

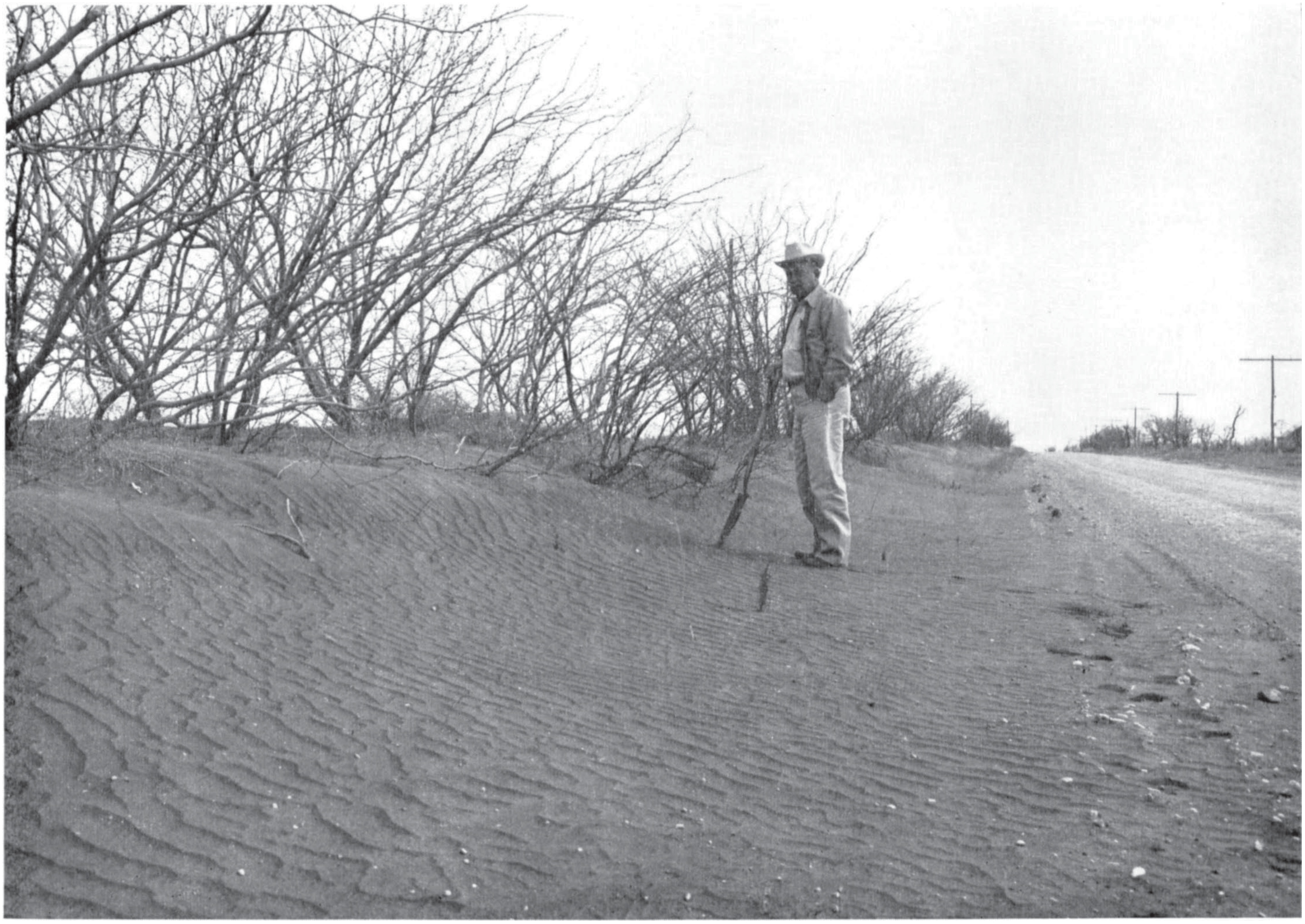

Figure 8.—**Soil material blown onto Portales clay loam, 0 to 1 percent slopes, from nearby cultivated field.**

races are not needed for erosion control, but they help in conserving water. (Capability unit IIce-5; Deep Hardland range site)

Portales clay loam, 1 to 3 percent slopes (PoB).—This soil is on smooth upland plains. It occurs in most parts of the county. The areas are irregularly shaped and range from 15 to 200 acres in size. Included in mapping were spots of Rowena clay loam, which make up about 3 percent of a mapped area.

The surface layer and the subsoil of this Portales soil are commonly thinner than those in the profile described as typical for the series, and the depth to the layer of accumulated lime is about 24 inches. In about 60 percent of the areas, this limy layer is cemented and there is soil material between the cemented fragments and in the cracks. In the rest of the areas, this limy layer is soft and has lime concretions in places.

This soil is well suited to locally grown crops. If well managed, it can be cropped fairly intensively. Most of the acreage is cultivated. Water erosion is a moderate hazard in clean-tilled areas. Soil blowing is a slight hazard. Reducing the amount of runoff, preserving tilth, and maintaining productivity are the main considerations. Using terraces and contour cultivation and growing grain sorghum or other crops that leave large amounts of stubble (fig. 9) help in controlling erosion. Keeping stubble on or near the surface improves tilth and fertility. (Capability unit IIe-2; Deep Hardland range site)

Potter Series

The Potter series consists of nearly level to moderately steep soils that are less than 10 inches deep over cemented caliche (fig. 10). Slopes are convex. These soils developed in plains outwash.

In a typical profile the surface layer is grayish-brown clay loam about 6 inches thick. This layer is 5 to 15 percent strongly cemented caliche fragments. The next layer is white, somewhat platy caliche. Below a depth of 15 inches is pinkish-white, weakly and strongly cemented caliche.

These soils have rapid runoff. They take in water readily but have only a low available water capacity.

A typical profile of a Potter clay loam is 200 feet west of farm road 2111 at a point 0.9 mile north of its intersection with Texas Highway 158. The intersection is 7.7 miles west of Ballinger.

A1—0 to 6 inches, grayish-brown (10YR 5/2) clay loam, dark grayish brown (10YR 4/2) when moist; weak subangular blocky structure; firm when moist, hard when dry; 5 to 15 percent strongly cemented caliche fragments 1/16 inch to 1½ inches in diameter; a few small, waterworn quartz pebbles; calcareous; moderately alkaline; abrupt boundary.

R&Cca—6 to 15 inches, white (N/8) somewhat platy caliche, weakly to strongly cemented in the upper part; clay loam between the plates makes up about 5 percent of mass.

R—15 to 36 inches +, pinkish-white (7.5YR 8/3), weakly and strongly cemented caliche.

The thickness of the A1 horizon is dominantly about 6 inches but ranges from 3 to 10 inches. In dry soil the colors range from brown to dark grayish brown in hue of 7.5YR to 10YR, value of 4 or 5, and chroma of 2 or 3. In some areas the A1 horizon, when moist, has a color value of less than 3.5. In these areas this horizon is less than 7 inches thick. The textures are fine sandy loam, loam, sandy clay loam, clay loam, and silty clay loam. The gravel content of the A1 horizon ranges from a small amount to as much as 35 percent of the soil mass. In most profiles, the gravel occurred as angular, cemented caliche fragments, and in some, as rounded siliceous pebbles.

The thickness of the Cca horizon ranges from several inches to several feet. Only the uppermost 2 to 10 inches is cemented. Cementation is strongest at the top of this horizon and diminishes in strength with increasing depth.

Potter soils are near Mereta and Vernon soils. They have a lighter colored surface layer and are shallower over caliche than Mereta soils. They are shallower and less clayey than Vernon soils, which overlie reddish shaly clays. They differ from Tarrant and Talpa soils in overlying caliche instead of limestone.

Potter soils (Pt).—These soils occur throughout the outwash plains on generally convex slopes ranging from 2 to 20 percent. They cap the low hills in the western and northern parts of the county. The more sloping parts of the landscape are occupied by Vernon soils, and the less sloping parts by Mereta clay loam. Included in mapping were spots of Mereta clay loam, which make up about 3 percent of the total acreage, and spots of Vernon, Portales, and other soils, all of which make up about 4 percent of the total acreage.

Nearly all of the acreage is rangeland. The vegetation is chiefly short grasses and shrubs. If these soils have a good cover of vegetation, the erosion hazard is slight, but if they are bare of vegetation, erosion is rapid and damage is severe. A good vegetative cover is the only means of con-

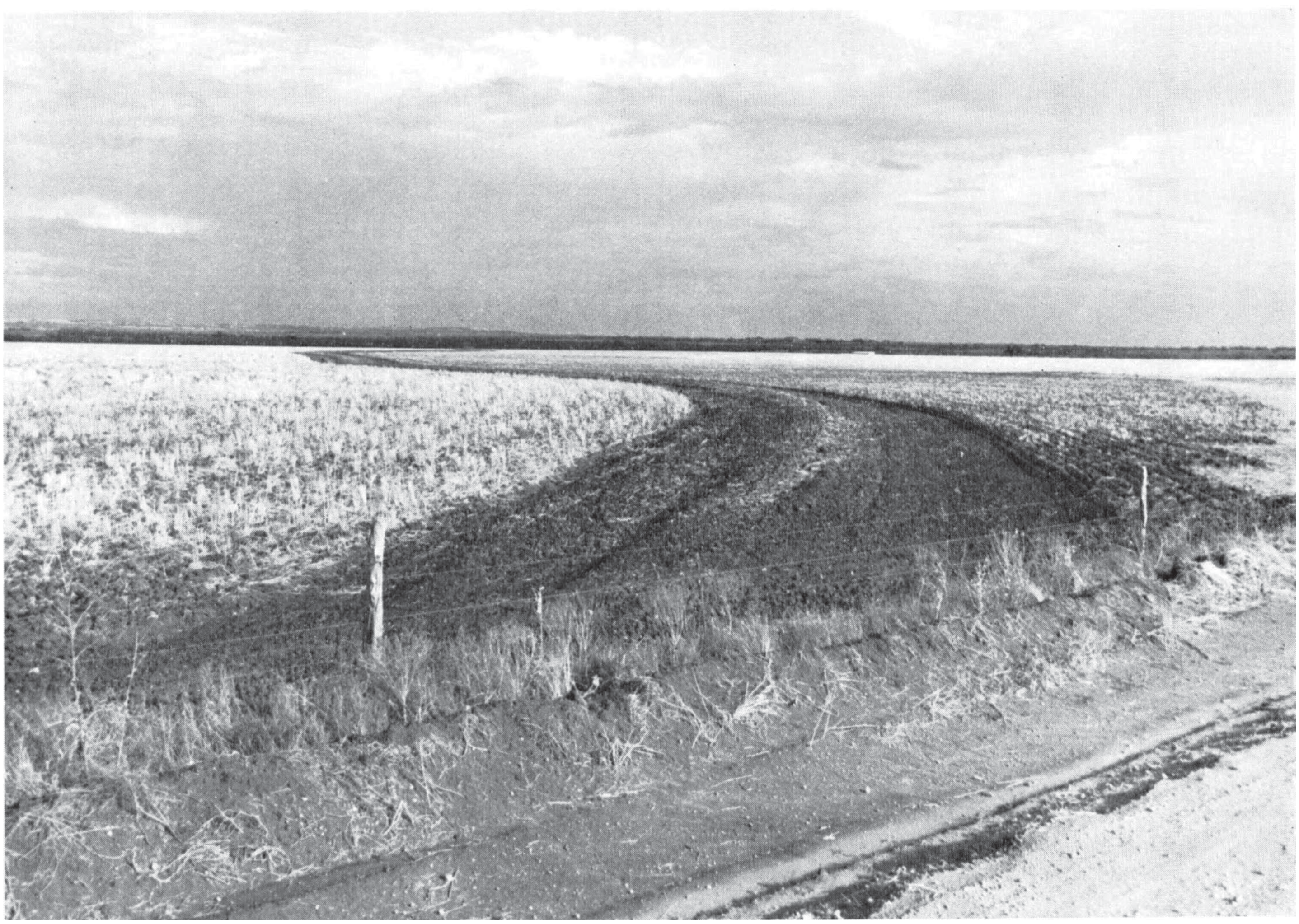

Figure 9.—Good stubble cover on area plowed with chisel type implement. Poor cover on plowed and disked terrace (center). The soil is Portales clay loam, 1 to 3 percent slopes.

Figure 10.—**Cemented caliche 8 to 11 inches below surface in Potter soil. The material below a depth of 1 foot is easily cut with a spade. The dark-colored area below the caliche is an old, filled-in animal burrow.**

trolling runoff and conserving moisture. The areas adjacent to or within cultivated fields are well suited to plantings for wildlife food and cover. They need to be fenced off to prevent grazing by livestock. (Capability unit VIIs-1; Very Shallow range site)

Rough Stony Land

Rough stony land (Ro) consists of steep limestone hills that have a thin, patchy covering of soil material over limestone and chalky marl. The gradient ranges from 20 percent to vertical. There is a difference of 200 to 400 feet between the highest and lowest parts. This land type is in the northeastern part of the county. A typical area is 22 miles northeast of Ballinger on farm road 382.

More than 75 percent of the surface of this land type is covered with loose limestone fragments that range in size from fine pebbles to boulders 30 feet in diameter, and 15 percent is covered with limestone outcrops. Included in mapping were a few sandy areas and a few exposures of red marine clay. These inclusions occur near the base of the steep hills.

Except in deep pockets between stones and upslope from boulders, the soil material is 0 to 3 inches thick. In the steepest parts the material is grayish-brown, strongly calcareous clay or marl. In the rest it is dark grayish-brown, moderately granular, calcareous clay or clay loam.

Rough stony land is closely associated with Tarrant soils but is steeper and has more coarse fragments than those soils.

This land type affords only light grazing. The vegetation is a thin to moderately thick stand of mid grasses and shrubs. Preserving the vegetation is important because a good stand in and around the cracks and crevices of rock exposures is the only effective means of controlling erosion and conserving moisture. Runoff is rapid, and moisture storage is limited. Brush control is difficult because of the steep slopes and in many places is undesirable because the woody plants provide shelter and browse for wildlife and livestock. Areas of Rough stony land make good wildlife habitat. (Capability unit VIIs-3; Steep Rocky range site)

Rowena Series

The Rowena series consists of deep, nearly level to gently sloping, calcareous silty clay loams, clay loams, and light clays. These soils are on the outwash plain. They have a smooth surface. They developed in deposits of calcareous clay loam and clay, some of which were waterlaid and some eolian.

In a typical profile the surface layer is dark grayish-brown heavy clay loam about 9 inches thick. The subsoil is brown heavy clay loam to light clay. It extends to a depth of 37 inches. Below this is a 12-inch layer of pink silty clay loam that is about 35 percent lime (fig. 11). Below a depth of 49 inches is pink clay loam. In dry soil there are cracks about $\frac{1}{4}$ to 1 inch wide and 12 inches or more long.

Rowena soils have slow to medium runoff, a moderately slow to slow water-intake rate, and a high available water capacity.

A typical profile of a Rowena clay loam is 120 feet south of a county road from a point on the county road 0.5 mile east and 4 miles south of U.S. Highway 67. The intersection of the county road and U.S. Highway 67 is 1.9 miles east of Rowena.

Ap—0 to 4 inches, dark grayish-brown (10YR 4/2) heavy clay loam, very dark grayish brown (10YR 3/2) when moist; weak subangular blocky and granular structure; firm when moist; hard when dry; thin surface crust; calcareous; moderately alkaline; abrupt, smooth boundary.

A1—4 to 9 inches, dark grayish-brown (10YR 4/2) heavy clay loam, very dark grayish-brown (10YR 3/2) when moist; weak subangular blocky structure; firm when moist, very hard when dry; few very small tubes; calcareous; moderately alkaline; clear, smooth boundary.

B21—9 to 18 inches, brown (10YR 4/3) heavy clay loam, dark brown (10YR 3/3) when moist; moderate, fine and very fine, subangular blocky and angular blocky structure; firm when moist, very hard when dry; a few very small tubes; a few limestone fragments $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter; calcareous; moderately alkaline; clear, wavy boundary that has a maximum of 7 inches between highs and lows.

B22—18 to 37 inches, brown (7.5YR 5/3) light clay, dark brown (7.5YR 4/3) when moist; moderate, fine to medium, angular blocky structure; firm when moist, extremely hard when dry; a few tubes and insect burrows; a few limestone fragments $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter; shiny pressure faces on ped surfaces; a few calcium concretions $\frac{1}{16}$ to $\frac{1}{4}$ inch in diameter in the lowermost 3 inches, which is a thin, discontinuous B3ca horizon; calcareous; moderately alkaline; gradual, wavy boundary that has a maximum difference of 12 inches between the highs and lows over a distance of 36 inches.

C1ca—37 to 49 inches, pink (7.5YR 8/3) silty clay loam, reddish yellow (7.5YR 6/6) when moist; weak subangular blocky structure; firm when moist, very hard when dry; a few weakly and strongly cemented calcium carbonate concretions $\frac{1}{8}$ inch to $1\frac{1}{2}$ inches in diameter; about 35 percent of soil mass is powdery calcium carbonate; calcareous; moderately alkaline; gradual boundary.

C2—49 to 60 inches +, pink (7.5YR 7/4) clay loam, strong brown (7.5YR 5/6) when moist; structureless; firm when moist, hard when dry; few tubes and earthworm casts; about 15 percent of soil mass is visible calcium carbonate.

The thickness of the A horizon ranges from 5 to 12 inches. In dry soil the color ranges from dark brown to dark grayish brown in hue of 10YR and 7.5YR, value of 4 or 5, and chroma of 2 or 3. In moist soil the value is less than 3.5 to a depth of more than 10 inches. The material is weakly to strongly calcareous except in a few profiles in areas of rangeland, where it is noncalcareous.

The thickness of the B21 horizon ranges from 5 to 10 inches. In dry soil the color ranges from brown to very dark grayish brown in hue of 10YR to 7.5YR, value of 3 or 4, and chroma of 2 or 3. The structure is weak to moderate, fine to medium, subangular blocky to angular blocky.

The thickness of the B22 horizon ranges from 10 to 34 inches. In dry soil the color is brown or dark brown in hue of 7.5YR to 5YR, value of 3 to 5, and chroma of 2 to 4. The structure is moderate, fine to medium, angular blocky. In the thicker B2 horizons the structure is weaker and the color lighter in the lowermost 2 to 6 inches.

The depth to the C1ca horizon ranges from 24 to 40 inches. The thickness ranges from 6 to 16 inches. In dry soil the color ranges from pink to light brown in hue of 5YR to 7.5YR, value of 5 to 8, and chroma of 3 to 6. This horizon is 15 to 60 percent lime.

Near Rowena soils are Tobosa soils, small depressed areas of Lipan soils, and a few low ridges of Portales and Mereta soils. Rowena soils are less gray than Lipan soils and are more clayey than Mereta and Portales soils. They are less clayey than Tobosa soils and have a B2 horizon, which Tobosa soils lack.

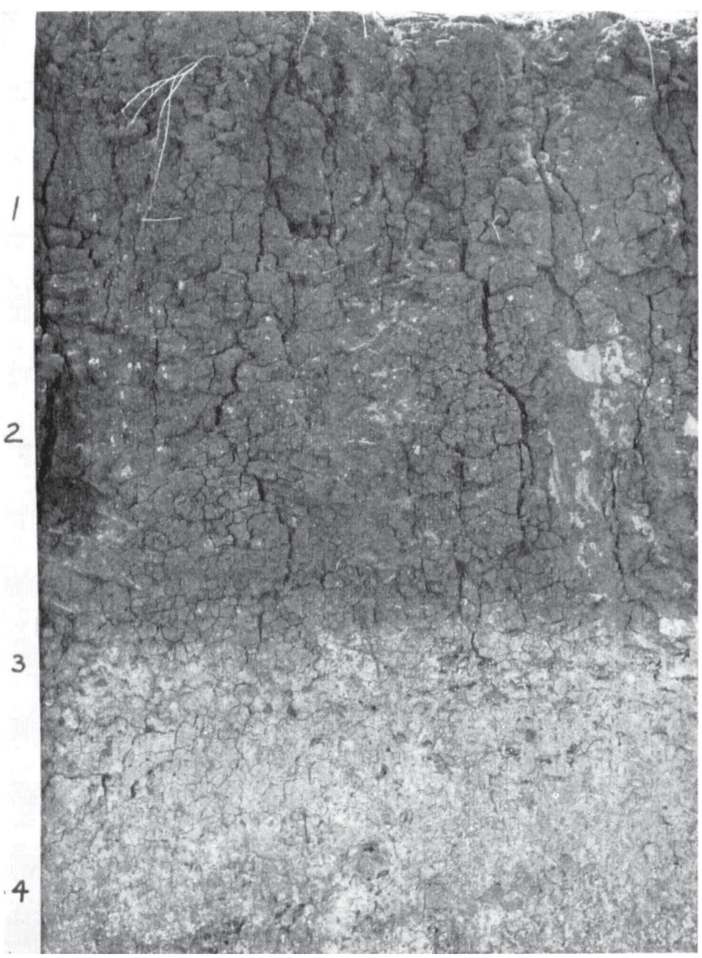

Figure 11.—**Profile of a Rowena clay loam. Lime has accumulated at a depth of 3 to 4 feet.**

Rowena and Tobosa soils, 0 to 1 percent slopes (RtA).—These soils occur as smooth scattered areas throughout the outwash plains. The Tobosa soil is nearly level, has a con-

Figure 12.—Dryland grain sorghum on terraced Rowena and Tobosa soils, 0 to 1 percent slopes.

cave surface, and occurs within larger areas of Rowena soils. Rowena clay loam occupies about 80 percent of each mapped area, and Tobosa clay about 15 percent. Included in mapping were small areas of Olton, Portales, and Mereta soils, all of which make up about 5 percent of the acreage.

The Rowena soil has the profile described as typical for the Rowena series. The Tobosa soil has the profile described as typical for the Tobosa series. It is described under the heading "Tobosa Series."

These soils make good cropland, and most of the acreage is cultivated. Natural fertility is high. There is little or no hazard of water erosion and only a slight hazard of soil blowing. Although terraces are not needed for erosion control, they help in conserving moisture (fig. 12). Because of the high clay content, the surface layer of the Tobosa soil is difficult to keep in good tilth. Growing sorghum, small grain, or other crops that leave large amounts of stubble is important in preserving tilth and in reducing the hazard of soil blowing. (Capability unit IIce-4; Rowena soils in Deep Hardland range site; Tobosa soils in Deep Upland range site)

Rowena and Tobosa soils, 1 to 3 percent slopes (RtB).—These soils occur as scattered areas throughout the outwash plains. The Tobosa soil is generally in shallow, poorly drained drainageways. The Rowena soil occupies areas that slope down to the drainageways. Rowena clay loam makes up about 80 percent of each mapped area, and Tobosa clay about 15 percent. Included in mapping were small areas of Olton, Portales, and Mereta soils, all of which make up about 5 percent of the acreage.

These soils make good cropland, and most of the acreage is cultivated. Natural fertility is high. Because of the high clay content, the surface layer of the Tobosa soil is difficult to keep in good tilth. The risk of soil blowing is slight, and that of water erosion moderate. Sorghum, small grain, or some other crop that leaves large amounts of stubble should be grown frequently. Tillage should be on the contour. Terraces are needed. Unless terraced, these soils should be in small grain continuously or in permanent pasture. (Capability unit IIIe-2; Rowena soils in Deep Hardland range site; Tobosa soils in Deep Upland range site)

Spur Series

The Spur series consists of deep, calcareous, loamy soils on flood plains. These soils occur along all of the major streams in the county. They are gently sloping along filled-in stream channels and nearly level in other places.

In a typical profile the surface layer is dark-brown loam about 18 inches thick. The subsoil is reddish-brown loam. It extends to a depth of 32 inches. Below this is reddish-brown loam that is slightly redder than the subsoil.

These soils have slow runoff, a moderate water-intake rate, and a high capacity for holding water and plant nutrients.

A typical profile of Spur loam is 90 feet east of farm road 53 from a point 1.2 miles north of Wingate.

Ap—0 to 4 inches, dark-brown (7.5YR 4/2) loam, dark brown (7.5YR 3/2) when moist; weak subangular blocky structure; friable when moist; slightly hard when dry; thin surface crust; calcareous; moderately alkaline; abrupt, smooth boundary.

A1—4 to 18 inches, dark-brown (7.5YR 4/2) loam, dark brown (7.5YR 3/2) when moist; moderate, fine and very fine, subangular blocky structure; firm when moist, hard when dry; tubes and pores are common; many earthworm casts; many threads of calcium carbonate; calcareous; moderately alkaline; diffuse, smooth boundary.

B2—18 to 32 inches, reddish-brown (5YR 4/4) loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure; firm when moist, hard when dry; insect burrows are common; many threads of calcium carbonate; calcareous; moderately alkaline; diffuse boundary.

C—32 to 84 inches +, reddish-brown (5YR 5/4) loam, yellowish red (5YR 4/6) when moist; structureless; firm when moist, hard when dry; calcareous; moderately alkaline.

The texture of the A horizon ranges from loam and clay loam to silty clay loam. The thickness ranges from 14 to 20 inches. In dry soil the color ranges from reddish brown to grayish brown in hue of 5YR to 10YR, value of 3 to 5, and chroma of 2 to 4. In moist soils the color value is less than 3.5 to a depth of more than 10 inches.

The texture of the B2 horizon also ranges from loam and clay loam to silty clay loam. The clay content is 18 to 35 percent. The thickness ranges from 8 to 40 inches. In dry soil the color ranges from reddish gray or dark reddish brown to brown in hue of 5YR to 7.5YR, value of 4 or 5, and chroma of 2 to 4.

The color of the C horizon is slightly redder and one or two units lighter in value than that of the B2 horizon. Stratification with sandy or gravelly soil is common.

Spur soils are more clayey than Yahola soils, which are associated bottom-land soils that have a subsoil of fine sandy loam.

Spur loam (Sp).—This soil occurs as long narrow areas on the higher parts of the flood plain. Although most of it is nearly level, there are short gentle slopes along filled-in stream channels. Flooding occurs once in 1 to 20 years and lasts less than 2 days. Included in mapping were a few areas of Colorado and Yahola soils. These areas are adjacent to stream channels, are no more than 200 feet wide, and make up about 8 percent of each mapped area.

This soil makes good cropland. The extra water received as runoff from adjacent higher lying soils and from the occasional floods is beneficial to crops. Natural fertility is high. About two-thirds of the acreage is cultivated, and the rest is used as pasture, range, or wildlife habitat. A few trees grow in most areas. Terraces are not ordinarily used. They are not needed for erosion control, and they are likely to be destroyed during periods of flooding. Deep cuts and fills for leveling are possible, because the surface layer and subsoil are of similar texture, but the effects of leveling may be destroyed through scouring and sedimentation by floodwater. Growing sorghum, small grain, and other crops that leave large amounts of residue helps in preserving and improving tilth. Areas bare of vegetation are severely damaged during floods. (Capability unit IIce–1; Loamy Bottomland range site)

Stamford Series

The Stamford series consists of dominantly gently sloping, calcareous clays that are underlain by red marine clay. Slopes are smooth and convex. In undisturbed areas the landscape is one of microrelief; microdepressions are 4 to 8 inches lower than microknolls.

The layers in a typical profile are reddish-brown clay to a depth of 45 inches. The surface layer is about 10 inches thick, the next layer about 20 inches thick, and the one below that about 15 inches thick. Below a depth of 45 inches is weak-red clay weathered from red marine clay.

These soils crack when dry and in most years remain cracked for as long as 150 days. The cracks are 1/2 inch to 4 inches wide and extend to a depth of about 2 feet. The capacity to hold water is high, but runoff is medium to rapid and water intake is slow.

A typical profile of Stamford clay, 0 to 1 percent slopes, is 100 feet north of a county road from a point on the county road 4.1 miles north and 0.5 mile west of U.S. Highway 67. The intersection of the county road and U.S. Highway 67 is 12.5 miles west of Ballinger.

A1—0 to 10 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate, fine, subangular blocky structure; when dry, soil naturally separates to a mass of extremely hard fine peds; calcareous; moderately alkaline; gradual boundary.

AC1—10 to 30 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate, medium and coarse, angular blocky structure; few parallelepipeds, the long axes of which are tilted more than 10 degrees from the horizontal; very firm when moist, extremely hard when dry; calcareous; moderately alkaline; gradual boundary.

AC2—30 to 45 inches, reddish-brown (2.5YR 5/4) clay, reddish brown (2.5YR 4/4) when moist; few intersecting slickensides; moderate, coarse, angular blocky structure; common parallelepipeds, the long axes of which are tilted more than 10 degrees from the horizontal; very firm when moist, extremely hard when dry; calcareous; moderately alkaline; gradual boundary.

C—45 to 54 inches +, weak-red (10YR 5/3) clay, weak red (10YR 4/3) when moist; slightly weathered red marine clay.

The thickness of the A horizon ranges from 6 to 15 inches. In dry soil the color ranges from reddish brown to dark reddish brown in hue of 2.5YR to 5YR, value of 3 or 4, and chroma of 2 to 4. In moist soil the value is less than 3.5 to a depth of more than 12 inches.

The thickness of the AC horizon ranges from 20 to 36 inches. In dry soil the color ranges from reddish brown to dark reddish brown in hue of 2.5YR, value of 3 or 4, and chroma of 2 to 4.

Some of the profiles observed have a Cca horizon, less than 6 inches thick, that contains few to many soft masses of calcium carbonate or a few concretions 1/16 to 3/4 inch in diameter.

The depth to the C horizon ranges from about 36 to 50 inches. The material is slightly weathered, calcareous, red marine clay. Beneath some profiles this material is practically unweathered.

Stamford soils are near Vernon, Weymouth, and Olton soils. They are deeper than Vernon soils and are more clayey, less friable, and less limy than Weymouth soils. They are more clayey in the A horizon than Olton soils and do not have the horizon of accumulated clay that is typical of those soils.

Stamford clay, 0 to 1 percent slopes (StA).—This soil occurs in the northern and northeastern parts of the county and north of Rowena and Miles. It has the profile described as typical for the series. Included in mapping were spots of Rowena, Tobosa, and Miles soils, in about equal parts. These spots make up about 5 percent of the total acreage.

This soil receives some runoff from higher lying soils. About half the acreage is cropland, and the rest is rangeland. The clay is hard to keep in good tilth. It shrinks and cracks when dry and swells when wet. During dry periods, cracks extend deep into the subsoil. Runoff rapidly enters these cracks, wets the soil deeply in spots, and thus causes pressure on structures and utility poles. In a few spots where gullies have formed, these cracks bring about an unusual type of erosion. Runoff enters the cracks and emerges at the gullies, thus forming tunnels that increase in size each time it rains. The tunnels eventually collapse, and thus new gullies form. Because of the slow water intake, there is much runoff, and because of the fine clay texture, soil moisture becomes slowly available to plants. Large amounts of organic matter are needed to slow down runoff, improve tilth, and increase water intake. Terraces help in conserving moisture but are not needed for control of erosion. Sorghum, small grain, and other high-residue crops should be grown most of the time. (Capability unit IIIs–2; Clay Flats range site)

Stamford clay, 1 to 3 percent slopes (StB).—This soil occurs in the northern and northeastern parts of the county. It is closely associated with Stamford clay, 0 to 1 percent slopes, but it has more rapid runoff and is only about 36 inches deep over red marine clay. Included in mapping were spots of Vernon soils, which make up about 1 percent of each mapped area, and spots of unnamed soils, which make up about 3 percent of each area.

About half the acreage is cropland, and the rest is rangeland. The clay is hard to keep in good tilth. It shrinks and cracks when dry and swells when wet. During dry periods, cracks extend deep into the subsoil. Runoff enters these cracks rapidly, wets the soil deeply in spots, and thus causes pressure on structures and utility poles. In a few spots where gullies have formed, these cracks bring about an unusual type of erosion. Runoff enters the cracks and emerges at the gullies, thus forming tunnels that increase in size each time it rains. The tunnels eventually collapse, and thus new gullies form. Because of the slow water intake and the slope, there is much runoff, and because of the fine clay texture, soil moisture becomes slowly available to plants. Large amounts of organic matter are needed to slow down runoff, improve tilth, and increase permeability. Sorghum, small grain, or some other crop that leaves large amounts of residue should be grown frequently. Tillage should be on the contour. Terraces are needed. (Capability unit IVe–8; Clay Flats range site)

Talpa Series

The Talpa series consists of calcareous soils that are less than 10 inches deep over caliche-coated limestone. The landscape is one of rolling hills and generally complex slopes.

In a typical profile the surface layer is grayish-brown clay loam about 7 inches thick. It rests on caliche-coated limestone.

Talpa soils have rapid runoff, a moderate to moderately slow water-intake rate, and a low available water capacity.

In this county Talpa soils are mapped with Kavett soils.

A typical profile of a Talpa clay loam is 100 feet south of the pump station road and 17.7 miles southeast of Ballinger on this road.

A1—0 to 7 inches, grayish-brown (10YR 5/2) clay loam, very dark grayish brown (10YR 3/2) when moist; weak granular and subangular blocky structure; firm when moist, hard when dry; 15 percent hard caliche and limestone fragments; few earthworm casts and insect burrows; calcareous; moderately alkaline; abrupt boundary.

Rca—7 to 10 inches +, caliche-coated limestone; caliche-sealed cracks and crevices.

The texture of the A horizon is dominantly (about 55 percent) silty clay loam but ranges from silty clay loam and clay loam to loam. The clay content is 25 to 35 percent. The thickness of this horizon ranges from 4 to about 10 inches. In dry soil the color ranges from grayish brown and very dark grayish brown to brown in hue of 10YR, which is dominant, and 2.5Y. The value is 4 or 5, and the chroma 2 or 3. The content of limestone and indurated caliche fragments ranges from a few to about 35 percent of the soil mass, and the size from 1/16 inch to 16 inches across the long axes. In areas where Talpa soils are associated with rock outcrops, there are a few stones 10 to 30 inches in diameter on the surface.

The material under the A1 horizon consists either of strongly cemented caliche plates 3 to 15 inches across and 1/4 inch to 2 inches thick or of caliche concretions that are 3 to 6 inches in diameter, slightly flattened, and smooth on top and rough on the bottom. This material rests on limestone that has caliche coatings, 1/8 to 1/2 inch thick, that extend into the fractures.

Talpa soils are less clayey and contain fewer coarse fragments in the A horizon than Tarrant soils, and they are less clayey and shallower than Kavett soils. In contrast with Potter soils, they overlie caliche-coated, hard limestone instead of thick beds of caliche.

Talpa-Kavett complex (Tk).—This complex occurs east of Ballinger. It is about equal parts Talpa clay loam and Kavett silty clay. These soils are very shallow over alternate layers of hard limestone and yellow marl. The thickness of the limestone ranges from a few inches to 16 inches, and that of the marl from 1 to 4 feet. The landscape is one of low rolling hills. In most places the gradient is less than 8 percent, but in places it ranges to 20 percent. The outcrops of limestone on the hillsides are more resistant to weathering than those of marl. Consequently, the hillsides have a steplike appearance. Included in mapping were a few rock outcrops, which occur in the steeper parts; areas of Valera silty clay, which make up about 3 percent of each mapped area; and an unclassified alluvial material, which is in the deeper drainageways and which makes up about 3 percent of each area.

The Talpa soil has the profile described as typical for the series. The Kavett soil is described under the heading

"Kavett Series." It has a surface layer of dark grayish-brown, calcareous silty clay about 8 inches thick over a layer of slightly lighter colored silty clay. Below this is limestone that is thickly coated with strongly cemented caliche in the upper part.

Both soils contain few to many fragments of limestone and hard caliche. In areas where limestone crops out, the soils are stony and gravelly. In other areas they are only gravelly.

Runoff is rapid, and water intake is moderate to moderately slow. The available water capacity is low in the Talpa soil and moderate in the Kavett soil.

The Kavett soil, which is the deeper and the more productive of native vegetation, is most commonly between rock outcrops and in shallow drainageways. It is as much as 20 inches deep over limestone. This soil is suitable for cultivation, but it occurs as such small, narrow areas, generally less than 5 acres in size, and is so closely associated with the shallow Talpa soil that it cannot feasibly be managed separately. The proportion of this soil decreases with increasing gradient.

All of the acreage is rangeland. The erosion hazard is severe. If these soils are bare of vegetation, erosion is rapid and damage is severe. A good vegetative cover is the only means of controlling runoff and conserving moisture. The areas adjacent to or within cultivated fields are well suited to plantings for wildlife food and cover. They need to be fenced off to prevent grazing by livestock. (Capability unit VIIs-1; Talpa soils in Very Shallow range site; Kavett soils in Shallow range site)

Tarrant Series

The Tarrant series consists of nearly level to steep, clayey soils on uplands. These soils are 50 percent limestone fragments and are less than 12 inches deep over fractured limestone. The topography is hilly. The hilltops are gently sloping.

In a typical profile the A11 horizon is very dark grayish-brown clay about 9 inches thick. Below this is a 3-inch layer of platy limestone. At a depth of 12 inches is fractured, hard limestone.

These soils have rapid to medium runoff, a moderate water-intake rate, and a low available water capacity.

A typical profile of Tarrant stony clay, 0 to 8 percent slopes, is 100 feet east of farm road 382 from a point 23.3 miles northeast of Ballinger on that highway.

A11—0 to 9 inches, very dark grayish brown (10YR 3/2) clay; very dark brown (10YR 2/2) when moist; strong, very fine, subangular blocky structure; plastic when wet, firm when moist, hard when dry; about 55 percent fragments of limestone 1/8 inch to about 4 inches across the long axes; calcareous; moderately alkaline; abrupt boundary.

R&A12—9 to 12 inches, platy limestone up to 5 inches in diameter; 5 to 10 percent dark grayish-brown clay between plates; abrupt boundary.

R—12 inches +, fractured hard limestone.

The thickness of the A11 horizon ranges from 4 to 12 inches. In dry soil the color ranges from dark brown and grayish brown to very dark grayish brown in hue of 10YR and 7.5YR, value of 3 to 5, and chroma of 2 or 3. In moist soil the value is less than 3.5. This horizon is mildly alkaline to moderately alkaline in reaction and is noncalcareous in places. Limestone fragments on the surface and throughout the profile make up 50 to about 65 percent of the soil mass and range from 1/8 inch to 2 feet across the long axes. In some profiles the lowermost 2 or 3 inches of this horizon is browner and slightly less gray than the rest.

Most profiles have a combined 2- to 6-inch R and A12 horizon that consists of platy limestone fragments and only thin seams of soil between the plates. Some have thin seams of soil material between the underlying broken limestone at a depth of several feet. Roots are few to abundant in these thin seams.

If there is no noticeable displacement or tilting of the fractured limestone, the depth to the R horizon ranges from about 10 to 18 inches.

Tarrant soils are closely associated with Talpa, Valera, and Kavett soils. They are darker colored and more clayey than Talpa soils, and they are shallower over limestone than Valera and Kavett soils.

Tarrant stony clay, 0 to 8 percent slopes (TrC).—This soil is on limestone hilltops in the northeastern part of the county. The surface is convex. Included in mapping were outcrops of limestone, areas of very shallow, noncalcareous, dark reddish-brown silt loam, and areas of Kavett silty clay. The Kavett soil has a lighter colored layer just above the limestone than the Tarrant soil. These inclusions make up about 10 percent of each mapped area.

This soil has the profile described as typical for the series. It is about 10 inches deep. There are many fragments of limestone 1/8 inch to 2 feet in diameter on the surface and throughout the profile.

This soil is fertile and provides a wide variety of good forage for livestock and wildlife. The entire acreage is rangeland. The vegetation consists of mid and short grasses, many species of forbs, and many browse plants, including evergreens and mast-producing oaks. Small rains provide adequate moisture for some plant growth because runoff concentrates in the areas around the stones. Runoff is medium. The stones on the surface slow down runoff and therefore help in reducing the hazard of erosion. If this soil has a good cover of vegetation, the erosion hazard is slight, but if it is bare of vegetation because of overgrazing, erosion is rapid and damage is severe and irreparable. (Capability unit VIs-3; Low Stony Hill range site)

Tarrant stony clay, 8 to 30 percent slopes (TrD).—This soil is on hillsides in the northeastern part of the county. Rock outcrops were included in mapping. They make up about 5 percent of a typical area.

This soil is steeper, shallower, and lighter colored than the soil described as typical for the series. It also contains a larger number of limestone fragments and stones than that soil. The surface layer is typically grayish brown, about 6 inches thick, and about 60 percent limestone fragments and stones. Fragments and stones cover 30 to 85 percent of the surface.

This soil is fertile and provides a wide variety of forage. The entire acreage is used as range and wildlife habitat. The vegetation consists of mid and short grasses, many species of forbs, and many browse plants, including evergreens and mast-producing oaks. Light rains provide adequate moisture for some plant growth because runoff concentrates in the areas around the stones. Runoff is rapid. The stones on the surface retard runoff somewhat and therefore help in reducing the hazard of erosion. If this soil has a good cover of vegetation, the erosion hazard is slight, but if it is bare of vegetation because of over-

grazing, erosion is rapid and damage is severe and irreparable. (Capability unit VIs-4; Low Stony Hill range site)

Tivoli Series

The Tivoli series consists of deep, loose sands blown from alluvial deposits along the Colorado River. The only evidences of horizon development in these soils are accumulations of organic matter and darker colors in the uppermost few inches.

In a typical profile the surface layer is brown fine sand about 10 inches thick. Below a depth of 10 inches is light yellowish-brown fine sand.

These soils take in water at a rapid rate but have a low capacity for holding it. Runoff is negligible.

A typical profile of Tivoli fine sand is 200 feet west of a county road from a point 2.4 miles south of its intersection with Texas Highway 158. This intersection is 15.2 miles west of Ballinger.

A1—0 to 10 inches, brown (10YR 5/3) fine sand, dark brown (10YR 4/3) when moist; structureless; very friable when moist, loose when dry; neutral; clear, wavy boundary.

C—10 to 60 inches +, light yellowish-brown (10YR 6/4) fine sand, yellowish brown (10YR 5/4) when moist; structureless; loose when moist, loose when dry; neutral; gradual boundary.

There are a few waterworn pebbles on the surface where wind erosion has removed the finer particles.

The thickness of the A1 horizon ranges from 2 to 14 inches. In dry soil the color ranges from pale brown and grayish brown to light yellowish brown in hue of 10YR and 7.5YR, value of 5 to 7, and chroma of 2 to 4.

In dry soil the color of the C horizon is 1 unit lighter in value than that of the A1 horizon, and in some profiles, a little redder in hue.

The surface of Tivoli soils resembles that of Brownfield soils. Tivoli soils, however, do not have a Bt horizon. In contrast, Brownfield soils have a sandy clay loam Bt horizon within a depth of 40 inches.

Tivoli fine sand (Tv).—This soil occurs as small areas along the Colorado River, 5 to 50 feet higher than the flood plain. It has the profile described as typical for the series. The landscape is one of undulating plains, hummocks, rounded hills, and knolls. Dunes have formed in most areas. Some are 3 to 10 feet high, have a gradient of 3 to 8 percent, and are usually less than 200 feet wide. Some are as much as 20 feet high and have a gradient of 8 to 20 percent. Included in mapping were spots of Brownfield fine sand and Miles loamy fine sand. Each of these soils makes up about 1 percent of each mapped area.

This soil is not suitable for cultivation. It has a low clay content and consequently a low capacity for holding water and plant nutrients. It is highly susceptible to blowing. Plowing destroys the standing cover that is needed for protection against blowing, and establishing new growth is most difficult in areas where the soil is bare of vegetation and sand dunes are forming. Seedlings are likely to be covered with drifting sand or cut off by blowing sand. Much of the acreage was once cleared and used for cotton, sorghum, fruits, and vegetables, but most of it is now used as range. Maintaining a good vegetative cover is the best means of controlling soil blowing and conserving moisture. Fences are needed for control of grazing. (Capability unit VIIe-1; Deep Sand range site)

Tivoli-Brownfield fine sands (Tw).—This complex occurs above the flood plain of the Colorado River. It is 60 percent Tivoli soils and 40 percent Brownfield soils. In cultivated areas there are dunes 5 to 30 feet high and about 100 to 200 feet wide along each fence row around the 5- to 40-acre fields. Lower and wider dunes are scattered throughout the rest of the acreage. Slopes of this complex range from 3 to 20 percent. Included in mapping were a few spots of Brownfield fine sand from which all of the original surface layer has been removed.

The Tivoli soil in this complex has the profile described as typical for the series. The Brownfield soil is described under the heading "Brownfield Series." It has a surface layer of light-brown fine sand 20 to 40 inches deep over red sandy clay loam. The sandy clay loam extends to a depth of more than 50 inches.

If the Tivoli-Brownfield fine sands south of Ballinger were leveled, the fine sand would be 8 or 9 feet deep. Only an estimated 30 percent of this particular acreage has a layer of sandy clay loam within a depth of 40 inches.

These fine sands have a high water-intake rate and absorb all the rain that falls. There is very little runoff. The capacity for holding water and plant nutrients is low in the surface layer of both soils, moderate in the subsoil of Brownfield soils, and low in the subsoil of Tivoli soils. Soil blowing is a severe hazard.

These soils are not suitable for cultivation, because permanent cover is needed for protection against soil blowing. Establishing new growth is most difficult in plowed or overgrazed areas where sand dunes are forming. Seedlings are likely to be covered with drifting sand or cut by blowing sand. About half the acreage was once cultivated to cotton, sorghum, and other crops, but most areas are now used as range. Maintaining a good vegetative cover is the best means of controlling soil blowing and conserving moisture. Fences are needed for control of grazing. (Capability unit VIIe-1; Deep Sand range site)

Tobosa Series

The Tobosa series consists of nearly level to gently sloping, calcareous clays. These soils developed over outwash, marl, or limestone on plains and on concave valley floors. In undisturbed areas the landscape is one of microrelief; microdepressions are 5 to 8 feet wide and are 4 to 12 inches lower than microknolls.

In a typical profile the surface layer is dark grayish-brown clay about 20 inches thick. The next layer is grayish-brown clay about 30 inches thick. Below this is a 10-inch layer of light brownish-gray clay that is up to 40 percent lime. Below a depth of 60 inches is pale-brown clay.

These soils crack when dry and in most years remain cracked for more than 150 days. The cracks are 1/4 inch to 4 inches wide and extend to a depth of more than 30 inches. Water intake is slow in moist soil and rapid in dry, cracked soil. Runoff is very slow to medium, depending on the slope, and the available water capacity is high.

A typical profile of Tobosa clay, 0 to 1 percent slopes, is 100 feet south of the pump station road and 14.9 miles southeast of Ballinger on that road.

A11—0 to 8 inches, dark grayish brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; the uppermost 1 inch has a mulch of loose, very fine, very hard aggregates; moderate, very fine and fine, angular blocky structure; firm when moist, very hard when dry; calcareous; moderately alkaline; clear, smooth boundary.

A12—8 to 20 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; weak angular blocky structure; very firm when moist, extremely hard when dry; several cracks are 1 inch wide; calcareous; moderately alkaline; diffuse boundary.

AC—20 to 50 inches, grayish-brown (10YR 5/2) clay, dark brown (10YR 3/3) when moist; common wedge-shaped peds and parallelepipeds, the long axes of which are tilted 10 to about 45 degrees from the horizontal; common, grooved, intersecting slickensides; very firm when moist, extremely hard when dry; calcareous; moderately alkaline; gradual boundary.

Cca—50 to 60 inches, light brownish-gray (10YR 6/2) clay, dark grayish brown (10YR 4/2) when moist; structureless; very firm when moist, extremely hard when dry; a few soft masses of calcium carbonate; calcareous; moderately alkaline; gradual boundary.

C—60 to 80 inches +, pale-brown (10YR 6/3) clay, brown (10YR 5/3) when moist; fewer soft masses of calcium carbonate than in the Cca horizon; calcareous in soil matrix; moderately alkaline.

The thickness of the A11 and A12 horizons combined ranges from 12 to 30 inches. In dry soil the colors are in hue of 10YR, value of 3 to 5, and chroma of 2. In moist soil the value is 3.5 or less to a depth of more than 10 inches.

The thickness of the AC horizon ranges from 30 to 50 inches. In dry soil the color range is in hue of 10YR to 2.5YR, value of 3 to 6, and chroma of 2 or 3. Intersecting slickensides range up to at least 6 inches in width.

The content of calcium carbonate in the Cca horizon ranges from a few small masses and a few weakly to strongly cemented concretions to 40 percent of the soil mass.

In the eastern part of the county, limestone or marl is at a depth of 4 to 8 feet. In other parts of the county the underlying material is marl or outwash.

Tobosa soils are near Rowena, Lipan, Valera, Kavett, and Talpa soils. They are darker colored and less gray than Lipan soils and are deeper than Valera, Kavett, and Talpa soils. They are browner and less red than Stamford soils.

Tobosa clay, 0 to 1 percent slopes (TyA).—This soil occurs in all parts of the county. It occupies the valley floor in the area east of Ballinger and the higher parts of the landscape on the outwash plain. Part of the drainage from these areas is to intermittent lakes, the floors of which are occupied by Lipan clay. Included in mapping were spots of Valera silty clay, which make up less than 1 percent of each mapped area; spots of Rowena clay loam, which make up about 5 percent of each area; and where the Tobosa soil is underlain by limestone, spots of a deep, loamy, calcareous soil, which make up about 2 percent of the total acreage of each mapped area.

This soil has the profile described as typical for the series. When dry, it has cracks 4 inches wide that extend deep into the subsoil.

This soil is well suited to cultivation, and much of the acreage is farmed. Cotton and grain sorghum are the main crops. The clay is hard to keep in good tilth. Large amounts of organic matter are needed to preserve or improve tilth and increase water intake. Sorghum and small grain are examples of suitable high-residue crops. Most areas in the eastern part of the county are used as range. (Capability unit IIIs-2; Deep Upland range site)

Tobosa clay, 1 to 3 percent slopes (TyB).—This soil occurs in all parts of the county. Typically, it is in valleys that have poorly defined channels. Included in mapping were spots of Valera silty clay and spots of Rowena clay loam. Each of these soils makes up about 4 percent of each mapped area.

This Tobosa soil is suited to cultivation, and much of the acreage is farmed to cotton and sorghum. The surface layer is difficult to keep in good tilth. The water-intake rate is slow when the soil is moist but rapid when it is dry and cracked. Runoff is medium, and the risk of water erosion is moderate. Controlling runoff and reducing the hazard of erosion would improve yields. Sorghum, small grain, or some other crop that leaves large amounts of residue should be grown frequently. Tillage should be on the contour. Terraces are needed. Unless terraced, this soil should be in small grain continuously or in permanent pasture. Most areas in the eastern part of the county are used as range. (Capability unit IIIe-2; Deep Upland range site)

Valera Series

The Valera series consists of nearly level to gently sloping, moderately deep silty clays. These soils developed over limestone or marl. Slopes generally are smooth.

In a typical profile the surface layer is grayish-brown and dark grayish-brown silty clay about 20 inches thick. Next is a 4-inch layer of brown silty clay that contains accumulations of lime. Below this is a 6-inch layer of pale-yellow silty clay that is 50 percent lime (fig. 13). Below a depth of 30 inches are strata of caliche-coated limestone separated by strata of marl.

These soils crack when dry and in most years remain cracked for more than 150 days. The cracks are more than half an inch wide and extend to a depth of more than 20 inches. Water intake is moderately slow in moist soil and rapid in dry, cracked soil. Runoff is medium, and the available water capacity moderate to high.

A typical profile of Valera silty clay, 1 to 3 percent slopes, is 100 feet west of the pump station road and 14 miles southeast of Ballinger on that road.

Ap—0 to 6 inches, grayish-brown (10YR 5/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak subangular blocky structure; very firm when moist, very hard when dry; calcareous; moderately alkaline; clear boundary.

A1—6 to 20 inches, dark grayish-brown (10YR 4/2) silty clay; very dark grayish brown (10YR 3/2) when moist; moderate to strong, very fine to medium, subangular blocky structure; very firm when moist, very hard when dry; calcareous; moderately alkaline; clear boundary.

ACca—20 to 24 inches, brown (10YR 5/3) silty clay, dark brown (10YR 4/3) when moist; moderate to strong, very fine to medium, subangular blocky structure; very firm when moist, very hard when dry; a few calcium carbonate concretions ⅛ to ¼ inch in diameter; calcium carbonate much more diffuse than in A12 horizon; calcareous; moderately alkaline; clear boundary.

Cca—24 to 30 inches, pale-yellow (2.5Y 8/4) silty clay, light yellowish brown (2.5Y 6/4) when moist; about 50

Figure 13.—**Accumulation of lime just above hard limestone in Valera silty clay. The scale is in feet.**

percent calcium carbonate; concretions are ⅛ to ¼ inch in diameter; abrupt boundary.

R&Ccam—30 to 60 inches, limestone strata, the upper surface of which has a strongly cemented caliche coating about 1 inch thick; some fractures filled with reprecipitated calcium carbonate; thin limestone strata separated by strata of yellowish marl.

The thickness of the A horizon ranges from 14 to 26 inches. The texture ranges from silty clay and light clay to heavy silty clay loam. In dry soil the color ranges from grayish brown to dark grayish brown or dark brown in hue of 10YR, value of 4 or 5, and chroma of 2 or 3. In moist soil the value is less than 3.5. This horizon is moderately alkaline to mildly alkaline in reaction and calcareous to noncalcareous.

The thickness of the AC horizon ranges from 4 to 20 inches, and the texture from silty clay to clay. In dry soil the color ranges from brown to grayish brown in hue of 10YR and 2.5Y. In many profiles, the lowermost few inches of this horizon contains strongly cemented to indurated caliche, either as plates and flattened nodules 2 to 6 inches in diameter or as coatings on the limestone.

The depth to the caliche-coated limestone or indurated caliche ranges from 20 to 40 inches.

Valera soils are near Talpa, Kavett, and Tobosa soils. They are deeper than Talpa and Kavett soils and are shallower and less clayey than Tobosa soils.

Valera silty clay, 0 to 1 percent slopes (VaA).—This soil occurs east of Ballinger, on valley floors and on hilltops. Included in mapping were areas of Kavett silty clay, which is less than 20 inches deep, and areas of a deep, unclassified soil along drainageways. These inclusions occur as areas of less than 6 acres and make up about 5 percent of each mapped area.

This soil is deeper over limestone than the one in the profile described as typical for the series. It is mildly to moderately alkaline and calcareous to noncalcareous.

Although this soil is well suited to cultivation, most of the acreage is used as range. Water intake is slow, runoff is medium, and because of the fine clay, soil moisture becomes slowly available to plants. If cultivated crops are to be grown, large amounts of organic matter are needed for slowing down runoff, improving tilth, and increasing the water-intake rate. Sorghum, small grain, and other high-residue crops should be grown most of the time. Terraces help in controlling runoff and also in conserving moisture. (Capability unit IIIs–2; Deep Upland range site)

Valera silty clay, 1 to 3 percent slopes (VaB).—This soil occurs east of Ballinger, mainly on valley floors but also on hilltops and narrow ledges on hillsides. Included in mapping were spots of Tobosa, Kavett, and Talpa soils. The individual areas of these included soils range from 2 to 7 acres in size, and they total about 5 percent of the acreage of each mapped area.

This Valera soil has the profile described as typical for the series. It is calcareous throughout. The depth to limestone is about 30 inches but ranges from 20 to 36 inches.

Although this soil is well suited to cultivation, most of the acreage is used as range. The risk of soil blowing is only slight, but that of water erosion is moderate. Controlling runoff and reducing the risk of erosion improve yields of cultivated crops. Large amounts of organic matter are needed in cultivated areas. Sorghum, small grain, or some other crop that leaves large amounts of stubble should be grown frequently. Tillage should be on the contour. Terraces are needed. Unless terraced, this soil should be in small grain continuously or in permanent pasture. (Capability unit IIIe–2; Deep Upland range site)

Vernon Series

The Vernon series consists of gently sloping to steep, calcareous clays that are shallow over red marine clay. Slopes are complex.

In a typical profile the surface layer is reddish-brown clay about 6 inches thick. The subsoil is reddish-brown clay about 12 inches thick. Below a depth of 18 inches are unweathered red beds.

These soils have rapid runoff, a slow water-intake rate, and a low available water capacity.

The Vernon soils in this county are mapped with areas of Badland.

A typical profile of a Vernon clay is 50 feet east of a private road 3.5 miles north of farm road 1770. The intersection of the private road and farm road 1770 is 9 miles east of Winters.

A1—0 to 6 inches, reddish-brown (2.5YR 4/3) clay, dark reddish brown (2.5YR 3/3) when moist; weak blocky structure; very firm when moist, very hard when dry; few waterworn, siliceous pebbles ⅛ inch to 2 inches in diameter; few fine roots; calcareous; moderately alkaline; clear boundary.

B2—6 to 18 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; moderate, very fine, blocky structure; very firm when moist; very hard when dry; few shiny pressure faces on ped surfaces; no noticeable clay films; few, fine, waterworn, siliceous pebbles; calcareous; moderately alkaline; gradual boundary.

R—18 to 60 inches +, unweathered red beds; weak-red (10YR 5/4), compact, massive shaly clay, weak red (10YR 4/4) when moist; calcareous; moderately alkaline; bedding planes; a few siliceous pebbles.

There are few to many waterworn pebbles ⅛ to 2 inches in size scattered on the surface and throughout most profiles.

The thickness of the A horizon ranges from 4 to about 10 inches. The texture is either clay or silty clay. In dry soil the color is commonly reddish brown in hue of 5YR and 2.5YR, value of 4 or 5, and chroma of 3 or 4.

The thickness of the B2 horizon ranges from about 6 to 14 inches. In dry soil the color ranges from reddish brown to red, in hue of 2.5YR, value of 4 or 5, and chroma of 3 to 6.

The depth to the R layer ranges from 10 to 20 inches.

Vernon soils are near Stamford, Weymouth, Potter, and Olton soils. They are shallower and steeper than Stamford soils and are less limy and more clayey than Potter and Weymouth soils. They are shallower and more clayey than Olton soils, which have a developed Bt horizon.

Vernon-Badland complex (Vb).—This complex is 75 percent Vernon clay and 20 percent Badland. It occurs in the northern and western parts of the county. Most areas are about 60 acres in size, but some are as much as 200 acres. The Badland part occurs as steep, eroded spots within areas of the less sloping Vernon soils. Slopes are complex. The gradient is ordinarily about 12 percent but in places ranges to 25 percent. Included in mapping were spots of Stamford, Potter, and Weymouth soils, which together make up about 5 percent of each mapped area.

The Vernon soil has the profile described as typical for the series. Badland is described under the heading "Badland." The material is red marine clay that shows little or no evidence of soil development.

All of the acreage is rangeland. The Vernon soil produces moderate amounts of forage. The erosion hazard is only slight in areas protected by a good vegetative cover but severe in areas that are overgrazed (fig. 14) and bare of vegetation. Because of shallowness, the damage from erosion is severe. The Badland part of this complex produces little or no vegetation. Control of grazing is the best means of controlling runoff, reducing the risk of erosion, and conserving moisture. (Capability unit VIIe-2; Vernon soils in Shallow Redland range site; Badland not assigned to range site)

Weymouth Series

The Weymouth series consists of gently sloping to sloping, calcareous clay loams that developed over cal-

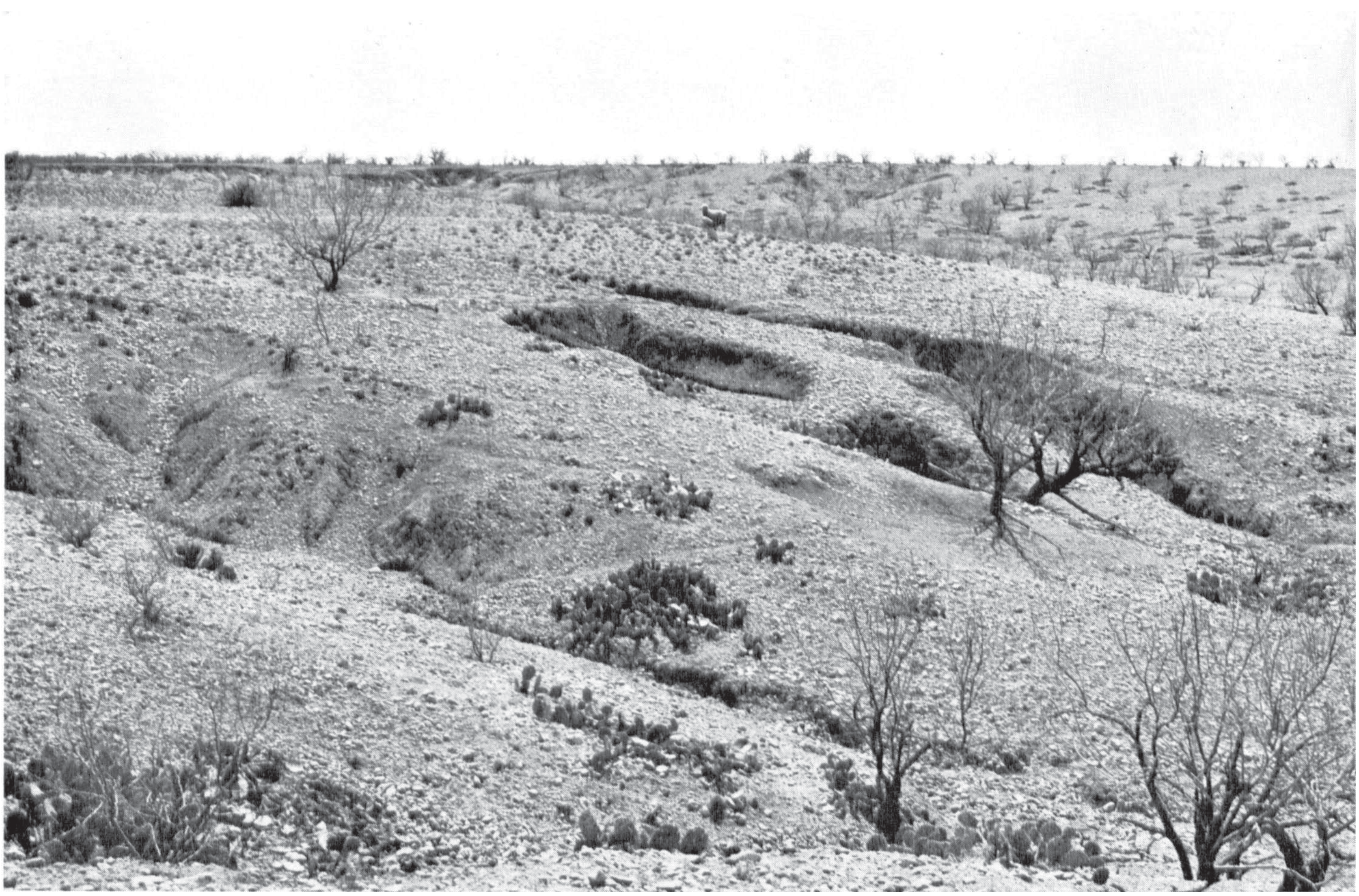

***Figure 14.*—Overgrazed area of Vernon-Badland complex.**

careous, reddish soil material of about clay loam texture. The surface is convex.

In a typical profile the surface layer is reddish-brown clay loam about 8 inches thick. The subsoil is red clay loam about 8 inches thick. Below this is an 8-inch layer of reddish-brown silty clay loam that is 15 to 75 percent lime. Below a depth of 24 inches is reddish-brown silty clay loam.

These soils have medium runoff, a moderate water-intake rate, and a moderate available water capacity.

A typical profile of Weymouth clay loam, 1 to 3 percent slopes, is 100 feet west of a county road at a point 9 miles north of its intersection with farm road 1770. The intersection of the county road and farm road 1770 is 2 miles east of Winters.

A1—0 to 8 inches, reddish-brown (5YR 4/3) clay loam, dark reddish brown (5YR 3/3) when moist; moderate, fine and very fine, subangular block structure; firm when moist, hard when dry; few waterworn pebbles ⅛ to ¾ inch in diameter; calcareous; moderately alkaline; clear, smooth boundary.

B2—8 to 16 inches, red (2.5YR 5.5/6) clay loam, dark red (2.5YR 3/6) when moist; moderate, fine and very fine, subangular blocky structure; firm when moist, very hard when dry; few waterworn pebbles ⅛ to ¾ inch in diameter; earthworm casts are common; calcareous; moderately alkaline; clear, smooth boundary.

C1ca—16 to 24 inches, reddish-brown (2.5YR 4/5) silty clay loam, dark reddish brown (2.5YR 3/5) when moist; weak, subangular blocky structure; firm when moist, hard when dry; about 15 percent soft calcium carbonate masses about ¼ inch in diameter; calcareous; moderately alkaline; gradual boundary.

C2—24 to 40 inches, reddish-brown (2.5YR 4/5) silty clay loam, dark reddish brown (2.5YR 3/5) when moist; structureless; much less calcium carbonate than in C1ca horizon; calcareous; moderately alkaline.

There are numerous waterworn pebbles on the surface in some places.

The thickness of the A horizon ranges from 7 to 14 inches. The structure ranges from moderate, fine, subangular blocky to moderate, medium, granular. In dry soil the color is dominantly reddish brown in hue of 5YR, value of 4, and chroma of 3 or 4.

The texture of the B2 horizon is dominantly clay loam but ranges to silty clay loam. The thickness ranges from 6 to 12 inches. In dry soil the color is reddish brown in hue of 5YR and 2.5YR, value of 3 to 6, and chroma of 3 to 6. The structure ranges from moderate, fine, subangular blocky to moderate, medium, granular.

The thickness of the C1ca horizon ranges from 6 to about 40 inches. The percentage of calcium carbonate ranges from 15 to 75 percent. The lime has accumulated as soft masses and weakly to strongly cemented concretions.

Weymouth soils are near Vernon, Stamford, and Olton soils. They are more limy and less clayey than Vernon and Stamford soils. They lack the clayey Bt horizon that is typical of Olton soils.

Weymouth clay loam, 1 to 3 percent slopes (WeB).—This soil is mainly in the northern and northeastern parts of the county, but there are a few areas in the southern part, north of Rowena and Miles. The slope is typically convex. Included in mapping were areas of Vernon soils and areas where the gradient is between 3 and 5 percent. Each of these inclusions makes up about 5 percent of each mapped area.

Most of the acreage is used as range, but part of it is planted to small grain, sorghum, or cotton. The risk of water erosion is moderate in areas bare of vegetation and in areas that have a thin vegetative cover. Controlling runoff, reducing the risk of erosion, and returning large amounts of organic matter to the soil are the main considerations in management. (Capability unit IIIe–7; Shallow Redland range site)

Winters Series

The Winters series consists of noncalcareous soils that have a distinct zone of accumulated calcium carbonate. These soils developed in old alluvium or plains outwash.

In a typical profile the surface layer is reddish-brown fine sandy loam about 10 inches thick. The subsoil is dark reddish-brown to red sandy clay about 40 inches thick. Below this is a 20-inch layer of light reddish-brown clay loam that is 20 percent lime. Below a depth of 70 inches is red clay loam.

These soils have slow to medium runoff, moderately slow water intake, and high available water capacity.

A typical profile of Winters fine sandy loam, 0 to 1 percent slopes, is in a field 1.75 miles north of the Runnels County courthouse; 800 feet north of a county road from a point 0.3 mile east of a low-water crossing on Elm Creek.

A1—0 to 10 inches, reddish-brown (5YR 5/4) fine sandy loam, dark reddish brown (5YR 3/4) when moist; structureless; very friable when moist, hard when dry; plowed in uppermost 8 inches; ¼-inch crust on surface; few, small, waterworn, siliceous pebbles; noncalcareous; moderately alkaline; clear boundary.

B21t—10 to 16 inches, dark reddish-brown (2.5YR 3/4) sandy clay, dark reddish brown (2.5YR 3/4) when moist; moderate, medium, subangular blocky structure; firm when moist, very hard when dry; many roots; few earthworm casts; few tubes and pores; few, small, siliceous pebbles; noncalcareous; moderately alkaline; clear boundary.

B22t—16 to 24 inches, dark-red (2.5YR 3/6) sandy clay, dark red (2.5YR 3/6) when moist; moderate to strong, medium, blocky structure; very firm when moist, very hard when dry; few, small, siliceous pebbles; most roots are between peds; clay films are nearly continuous; ped surfaces are darker colored than broken peds; noncalcareous; moderately alkaline; gradual boundary.

B23t—24 to 50 inches, red (2.5YR 4/6) sandy clay, dark red (2.5YR 3/6) when moist; moderate to strong, medium, blocky structure; very firm when moist, very hard when dry; few, small, siliceous pebbles; most roots are between peds; clay films are nearly continuous; ped surfaces are darker colored than broken peds; matrix is noncalcareous; a few soft masses of calcium carbonate below a depth of 36 inches; moderately alkaline; clear boundary.

B3ca—50 to 70 inches, light reddish-brown (2.5YR 6/4) clay loam, red (2.5YR 4/6) when moist; weak subangular blocky structure; firm when moist; hard when dry; 20 percent calcium carbonate, mostly soft masses with a few concretions 1/16 to ½ inch in diameter; calcareous; moderately alkaline; gradual boundary.

C—70 to 78 inches +, red (2.5YR 5/6) clay loam, red (2.5YR 4/6) when moist; structureless; firm when moist, hard when dry; few masses of calcium carbonate; calcareous; moderately alkaline.

The thickness of the A horizon ranges from 4 to 14 inches. In dry soil the color ranges from light reddish brown to brown in hue of 5YR to 7.5YR and value of 5 or 6. In moist soil the value is 3 or 4. The material is hard and massive.

In most profiles, the lower boundary of this horizon is clear, but in some of it is gradual.

The texture of the B2t horizon ranges from sandy clay to heavy clay loam. In dry soil the color ranges from red to reddish brown in hue of 2.5YR to 5YR.

The depth of the B3ca horizon ranges from about 38 to 60 inches. This horizon is more than 15 percent lime. The lime has accumulated as soft lumps and concretions that range from 1/16 to 1 inch in diameter.

Winters soils are more clayey in the subsoil than the nearby Acuff, Cobb, and Miles soils. They are more sandy and have less organic matter in the A horizon than Olton soils.

Winters fine sandy loam, 0 to 1 percent slopes (WnA).—This soil typically occurs as long areas along streams, 5 to 50 feet higher than the flood plain. Included in mapping were spots of Miles fine sandy loam, which make up about 3 percent of each mapped area, and spots of Brownfield fine sand, which make up about 1 percent of each area.

This soil has the profile described as typical for the series. The thickness of the surface layer is generally about 10 inches but ranges from 8 to 14 inches. The subsoil is red sandy clay. The soil material is moderately alkaline but is noncalcareous as far down as the lime zone, which is at a depth of about 50 inches. The underlying material is old alluvium or plains outwash of about clay loam texture.

This soil is well suited to cultivation. Most of the acreage is cultivated. Plant nutrients are readily leached from the surface layer, and fertilization is needed. The response to fertilization is good. The risk of soil blowing is moderate. Large amounts of stubble are needed. Sorghum and small grain are examples of suitable high-residue crops. (Capability unit IIIe-4; Sandy Loam range site)

Winters fine sandy loam, 1 to 3 percent slopes (WnB).—This soil is along the Colorado River, about 5 to 50 feet higher than the flood plain. Included in mapping were spots of Miles fine sandy loam. These spots make up about 3 percent of each mapped area.

This soil is eroded. The surface layer is 6 to 8 inches thick. In a few spots fine particles have been removed through soil blowing, and in some the surface layer has been mixed with material from the subsoil through plowing. Other evidences of erosion are a few shallow gullies and low sand dunes along fences or around plants.

This soil is well suited to cultivation. Most of the acreage is cultivated. Plant nutrients are readily leached from the surface layer, and fertilization is needed. The response to fertilization is good. The risks of soil blowing and water erosion are moderate. Large amounts of organic matter and stubble are needed. Sorghum and small grain are examples of suitable high-residue crops. In terracing and leveling, the depth of cuts and fills has to be limited because of the difference between the clay content of the surface layer and that of the subsoil. Areas in which the subsoil is exposed have poor tilth and low fertility. Unless terraced, this soil needs a dense cover of stubble on the surface to slow down runoff. (Capability unit IIIe-4; Sandy Loam range site)

Winters fine sandy loam, 1 to 3 percent slopes, eroded (WnB2).—This soil is in the northeastern part of the county, near the base of the limestone hills. Included in mapping were nearly level areas, which make up about 3 percent of each mapped area, and wooded areas where there is little or no erosion, which make up about 10 percent of each area.

About 60 to 75 percent of the original surface layer has been removed from this soil through water erosion. The present surface layer is about 5 inches thick. There are a few shallow gullies and a few deep, steep-sided gullies where water concentrates. The reaction is typically neutral but is slightly acid in some areas and moderately alkaline in areas where this soil receives runoff from limy soils. The layer of lime accumulation is at a depth of 38 inches.

Most of the acreage is rangeland. Areas formerly cultivated are now used as pasture. Plant nutrients are readily leached from the surface layer, and fertilization is needed. The response to fertilization is good. The risk of water erosion is moderate, and that of soil blowing moderate to severe. For cultivated crops, large amounts of organic matter and stubble are needed. Tillage should be on the contour. Terraces are needed. In terracing and leveling, the depth of cuts and fills has to be limited because of the difference between the clay content of the surface layer and that of the subsoil. Areas in which the subsoil is exposed have poor tilth and low fertility. This soil should be in small grain or grain sorghum each year or in permanent pasture. (Capability unit IVe-3; Sandy Loam range site)

Yahola Series

The Yahola series consists of deep, calcareous soils on flood plains. These soils occur along all of the larger streams in this county. They are nearly level except in a few spots along filled-in channels where they are gently undulating.

In a typical profile the surface layer is reddish-brown fine sandy loam about 6 inches thick. Below a depth of 6 inches is yellowish-red fine sandy loam stratified with loamy fine sand and very fine sandy loam.

These soils have very slow runoff, a moderately rapid water-intake rate, and a moderate available water capacity. They are flooded once in 1 to 5 years.

A typical profile of Yahola fine sandy loam is 0.6 mile east of U.S. Highway 83 and 7.0 miles north of Winters on that highway.

Ap—0 to 6 inches, reddish-brown (5YR 5/4) fine sandy loam, reddish brown (5YR 4/4) when moist; weak subangular blocky structure; very friable when moist, soft when dry; a few fine roots; a few threads of calcium carbonate; calcareous; moderately alkaline; clear boundary.

C—6 to 26 inches +, yellowish-red (4YR 5/8) fine sandy loam, yellowish red (4YR 4/8) when moist; structureless; very friable when moist, soft when dry; strata of loamy fine sand and very fine sandy loam ½ inch to 3 inches thick; bedding planes are evident; calcareous; moderately alkaline.

The texture of the A horizon ranges from very fine sandy loam to fine sandy loam. In dry soil the color ranges from reddish brown to brown in hue of 5YR to 7.5YR and value of 4 or 5.

The texture of the C horizon ranges from very fine sandy loam to loamy fine sand. The clay content is less than 18 percent. Particles coarser than very fine sand make up more than 15 percent of the soil mass at a depth between 10 and 40 inches. In dry soil the color ranges from yellowish red to reddish brown and brown in hue of 2.5YR to 7.5YR, value of 4 or 5, and chroma of 4 to 8.

Yahola soils are more sandy than the associated Spur and Colorado soils. They have a lighter colored surface layer than Spur soils.

Yahola fine sandy loam (Ya).—This soil occurs as long, narrow strips parallel to stream channels, a few inches to a few feet higher than the rest of the flood plain. It has the

profile described as typical for the series. The surface is smooth and convex. Slopes range from 0.5 to 1 percent. Flooding occurs once in 1 to 5 years and lasts less than 2 days. Included in mapping were areas of Spur and Colorado loams, which make up about 3 percent of each mapped area.

This soil makes good cropland. About half the acreage is cropland, and the rest is pasture or range. The runoff from adjacent higher lying soils and the extra water from the occasional floods are beneficial to crops. A water table at a depth of several feet provides adequate moisture for deep-rooted plants. The risks of soil blowing and of water erosion are only slight. Terraces are not ordinarily used. They are not needed for erosion control, and they are likely to be destroyed during periods of flooding. Leveling is not advisable because of scouring and sedimentation by floodwater. Growing small grain, sorghum, and other high-residue crops helps in preserving tilth. Many areas make good wildlife habitat. (Capability unit IIw-1; Loamy Bottomland range site)

Use and Management of the Soils

Runnels County is part of a region that is subject to frequent droughts, low rainfall in winter, dashing rainstorms in summer, high winds, and wide variations in temperature. Because of the climate, the choice of crops is limited. Cotton, wheat, oats, barley, and most grain and forage sorghums are among the crops suited to both the soils and the climate. All can be dry-farmed. Garden crops and orchard crops need to be irrigated.

In order to hold moisture on the soil until it soaks in and to reduce the amount lost through evaporation, farmers in this county rely on the following:

1. A cropping system or crop rotation that allows the soil to store moisture.
2. Crop stubble or a plant cover, to keep the soils from sealing or crusting under the impact of raindrops.
3. Contour farming and use of level terraces with closed ends.
4. Standing stubble, to slow down wind and catch snow.
5. Tillage that does not impair the water-intake rate. The soil is tilled when it is not wet enough to clod or pack and is tilled to varying depths to avoid the formation of a plowpan.
6. Weed control. Weeds use moisture that otherwise would be stored for crops.
7. A mulch of crop stubble, to shade and cool the soil and thus to reduce the amount of moisture lost through evaporation, slows down the drying effects of strong winds and slows down the rate of runoff.
8. Land leveling for even distribution of water.

The system of classifying soils according to their suitability for use is explained in the following paragraphs. Also, estimates of yields of the principal crops under defined levels of management are given.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The classification does not apply to most horticultural crops or to rice and other crops that have special requirements. The soils are classified according to degree and kind of permanent limitation but without consideration of major and generally expensive alterations in the slope, depth, or other characteristics of the soils; and without consideration of possible but unlikely major reclamation projects.

In the capability system, all the soils are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groups are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I. Soils have few limitations that restrict their use. (No class I soils in Runnels County.)

Class II. Soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (No class VIII soils in Runnels County.)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry. For some soils, climate and

one of the other limitations have about equal importance, and the subclass symbol shows both kinds; IIce is an example.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses identified by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding Arabic numerals to the subclass symbol, for example, IIe-2 or IIIe-4. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit. Capability unit numbers generally are assigned locally but are part of a statewide system. All of the units in the system are not represented by the soils of Runnels County; therefore the numbers are not consecutive.

The capability unit designations for all the soils in the county can be found in the "Guide to Mapping Units." The suitability of each soil for crops and suggestions for its management are given under the heading "Descriptions of the Soils." The capability unit is identified at the end of each soil description.

Estimated Yields

Estimated yields of the principal crops grown in Runnels County, under two levels of management, are shown in table 2. The estimates shown are for the soils now under cultivation. They are based on records kept at experiment stations and on information obtained from farmers and those who work with farmers. Yields vary considerably in this county because of the climate. For example, on one farm the yield of cotton on Rowena and Tobosa soils, 0 to 1 percent slopes, was 15 pounds per acre in 1956 and 519 pounds per acre in 1960.

The "A" columns in table 2 show the yields that can be expected under average management. Under average management—

1. Properly treated seeds of improved varieties are selected.
2. Maintenance of contours, terraces, and other structures for conservation of water and control of erosion is fair to good.

Table 2.—*Estimated yields per acre of major crops under two levels of management*

[Figures in columns A indicate yields under average management; figures in columns B indicate yields under improved management. Absence of figure indicates the crop is not commonly grown on the soil specified]

Soil	Cotton		Grain sorghum		Wheat	
	A	B	A	B	A	B
	Lb. of lint	*Lb. of lint*	*Lb.*	*Lb.*	*Bu.*	*Bu.*
Acuff loam, 0 to 1 percent slopes	190	240	1, 140	1, 600	13	19
Acuff loam, 1 to 3 percent slopes	170	220	1, 080	1, 200	10	13
Kavett silty clay, 0 to 1 percent slopes	130	190	660	840	9	11
Kavett silty clay, 1 to 3 percent slopes	100	140	570	720	8	10
Lipan clay	120	150	600	780		
Mereta clay loam, 0 to 1 percent slopes	130	180	750	800	9	11
Mereta clay loam, 1 to 3 percent slopes	110	160	660	720	8	10
Miles fine sandy loam, 0 to 1 percent slopes	170	290	840	1, 600	12	16
Miles fine sandy loam, 1 to 3 percent slopes	150	270	760	1, 500	11	15
Miles loamy fine sand, 0 to 3 percent slopes	130	260	800	1, 620	11	15
Olton clay loam, 0 to 1 percent slopes	180	220	1, 000	1, 260	13	18
Olton clay loam, 1 to 3 percent slopes	160	200	930	1, 140	10	13
Portales clay loam, 0 to 1 percent slopes	180	230	1, 100	1, 260	13	18
Portales clay loam, 1 to 3 percent slopes	160	210	980	1, 140	11	16
Rowena and Tobosa soils, 0 to 1 percent slopes	210	300	1, 250	1, 700	15	20
Rowena and Tobosa soils, 1 to 3 percent slopes	180	220	1, 100	1, 400	13	18
Spur loam	210	300	1, 140	1, 700	15	22
Stamford clay, 0 to 1 percent slopes	120	180	800	900	10	14
Stamford clay, 1 to 3 percent slopes	100	150	750	850	9	13
Tobosa clay, 0 to 1 percent slopes	130	190	880	1, 000	11	16
Tobosa clay, 1 to 3 percent slopes	110	170	800	900	10	14
Valera silty clay, 0 to 1 percent slopes	120	180	840	900	13	18
Valera silty clay, 1 to 3 percent slopes	110	170	800	850	9	13
Weymouth clay loam, 1 to 3 percent slopes	110	150	600	800	8	11
Winters fine sandy loam, 0 to 1 percent slopes	170	250	840	1, 600	11	15
Winters fine sandy loam, 1 to 3 percent slopes	150	220	810	1, 500	10	14
Winters fine sandy loam, 1 to 3 percent slopes, eroded	130	220	600	1, 020	7	13
Yahola fine sandy loam	190	300	1, 080	1, 500	13	15

3. Weed and insect control is usually good.
4. Tillage is somewhat excessive; sometimes tillage is done when the soil is wet.
5. Moderate amounts of organic matter are returned to the soil; occasionally grain stubble is overgrazed.
6. Emergency tillage is the principal measure taken for control of soil blowing.

The "B" columns show the yields that can be expected under improved management. Under improved management—

1. Proven varieties are planted at the ideal rate, at the best time, and at the right depth.
2. Crop stubble, contour cultivation, and terraces provide for conservation of water and control of erosion.
3. All cultivation is timed to take advantage of rainfall.
4. Weed and insect control is consistently effective.
5. Large amounts of organic matter are returned to the soil.
6. Cotton root rot and other plant diseases are kept to a minimum by using suitable crop rotations.
7. Fertilizer is applied in the amounts indicated by soil tests.

Use and Management of Rangeland[1]

About 373,600 acres in Runnels County is used as range. This acreage consists mainly of steep, shallow, and stony soils that generally are not suitable for cultivation, but it includes a significant acreage of soils that are suitable for cultivation.

Ranches are between 2,000 and 6,000 acres in size. Livestock farms, which outnumber ranches, have between 10 and 1,000 acres of rangeland as sources of forage. On these farms the stock is given supplemental forage and feed grown on cropland. The stock consists mainly of cattle and sheep breeding stock. In favorable years a few stocker-type lambs and calves are grazed, and also a few horses and goats.

The original plant cover in Runnels County consisted principally of short and mid grasses and associated forbs. Continuous, heavy grazing for many years has resulted in deterioration of the plant cover, excessive crusting of the soil, more rapid runoff, and lower forage production. The better forage plants have declined and have been replaced by weeds, brush, and shorter grasses.

Forage production is highest in April, May, and June. In most years, this is the period when rainfall is heaviest and temperature most favorable. Another growing season occurs in fall, usually during September and October. Rainfall is generally lighter during this period than in spring. Some growth of cool-season grasses and weeds occurs in winter.

Selecting the kind of livestock to which the range is well suited, limiting grazing to protect the plant cover, and making seasonal adjustments in the number of livestock to make the best use of the available forage are the principal management requirements.

Range Sites and Condition Classes

Rangeland is classified into range sites according to its capacity to produce native vegetation. Different kinds of range produce different kinds and amounts of vegetation. The inherent productive capacity of different areas of rangeland depends principally on the combined effects of the soils and the climate. Each range site has its own soils and environmental conditions, and these produce a characteristic plant community.

The plant community that uses the site fully and that successfully maintains and reproduces itself is called the potential, or the climax, for the site. Generally this mixture of plants grows on a site so long as the site is not overgrazed and the environment remains unchanged. Native plants are referred to as decreasers, increasers, and invaders. Decreasers and increasers are a part of the climax vegetation.

Livestock graze selectively and seek the plants that are the most palatable. Decreasers are steadily reduced or killed by heavy, continuous grazing. Increasers become more abundant when the decreasers begin to decline. Increasers are commonly shorter and less palatable than the decreasers. If the increasers are grazed heavily, they decline and are replaced by invaders. Invaders are plants normally not present in the original plant community. Many are plants not suitable for grazing, such as brush, and others are less palatable, low-growing grasses and weeds. Many are spiny and poisonous.

Range condition is determined by comparing the kinds and numbers of plants that make up the vegetative cover with those in the potential native plant cover for the same site. Range condition indicates the degree to which the composition of the existing plant community differs from the potential, or the climax, vegetation. Four classes are recognized. A range is in *excellent* condition if 76 to 100 percent of the vegetation is the same kind as that in the original stand; it is in *good* condition if the percentage is between 51 and 75; in *fair* condition if the percentage is between 26 and 50; and in *poor* condition if the percentage is 25 or less.

A range site in excellent condition is at or near its maximum productivity. A site in good condition has lost a few decreaser plants, but it is still productive and can be maintained and improved by good management of grazing. A site in fair condition has a severely altered plant community in which increasers dominate and invaders are becoming prominent. A site in poor condition has lost almost all of the desirable forage plants, has few plants that are part of the original vegetation, and has many invaders.

Good range management requires recognition of the range site and determination of range condition. Range that is kept in good or excellent condition provides optimum forage yields and is protected against excessive erosion and loss of water.

[1] By R. J. PEDERSON, range conservationist, Soil Conservation Service.

Descriptions of Range Sites

Twelve range sites are recognized in Runnels County. They are described on the pages that follow. In each description are estimates of total herbage yields when the site is in excellent condition. Yields are given in air-dry weight, one for favorable years and one for unfavorable years.

The "Guide to Mapping Units" shows the range site classification for each soil in the county.

Clay Flats range site

The soils in this site are nearly level to gently sloping, compact, reddish-brown clays. Slopes are smooth. Droughtiness is a limitation. These soils have much runoff because of slow water intake, and they store only a small amount of moisture that is available to plants because of their fine clay texture. Grassland recovery is slow.

For many years the trend in condition was downward. This deterioration nearly eliminated cane bluestem, side-oats grama, Arizona cottontop, and plains bristlegrass and left only tobosagrass and buffalograss. In recent years management has been good, and now much of the site has recovered.

Bare spots show up after several years of overgrazing. Seeding is often a failure because of droughtiness. Control of grazing is the best means of improving this site. Controlling the spread of brush, mainly mesquite, is a major problem.

Decreaser grasses in the potential plant community are buffalograss, Arizona cottontop, plains bristlegrass, and some side-oats grama and cane bluestem. Increasers are tobosagrass and three-awn. Common invaders are red grama, Texas grama, annual grasses, mesquite, cactus, bitterweed, and other annual weeds.

In favorable years herbage yield is 2,000 pounds per acre. In unfavorable years it is 1,200 pounds per acre.

Deep Hardland range site

This is one of the more productive sites in the county. The soils are nearly level to gently sloping, deep clay loams. The rate of water intake is moderate to moderately slow, runoff is slow, and the available water capacity is high. Fertility is high.

For many years the trend in condition has been downward because of continuous heavy grazing during and following periods of drought. Originally, the site was an open prairie of short and mid grasses and forbs. Now, buffalograss and mesquite trees are common and forage production is lower.

Control of mesquite and deferment of grazing would allow accumulation of mulch on the surface and encourage growth of the better species. Seeding can be done successfully after thorough tillage.

Decreaser grasses in the potential plant community are side-oats grama, vine-mesquite, and cane bluestem. Increasers are buffalograss, Texas wintergrass, tobosagrass, and curly mesquite. Desirable forbs, such as evening primrose, catclaw, sensitivebrier, gaura, and Engelmann daisy, are part of the climax plant community. Common invaders are red grama, Texas grama, annual grasses, mesquite, pricklypear, broomweed, bitterweed, and other annual weeds.

In favorable years herbage yield is 2,800 pounds per acre. In unfavorable years it is 1,500 pounds per acre.

Deep Upland range site

This is a productive site. The soils are depressed and nearly level to gently sloping, moderately deep to deep, firm clays. Some receive runoff from higher lying soils. The rate of water intake is moderately slow or slow, but these clays crack when dry and water enters rapidly through the cracks. Only a small amount of moisture is available to plants, however, because of the fine clay texture. If the range deteriorates to poor condition, recovery is extremely slow.

As a result of many years of continuous heavy grazing, the better forage plants have decreased and brush, weeds, and shorter grasses have increased. This deterioration has resulted in lower production, more soil crusting, and more runoff and erosion.

Control of mesquite and pricklypear combined with deferment of grazing is needed in most areas.

Cane bluestem, vine-mesquite, Arizona cottontop, and side-oats grama are major decreaser grasses in the potential plant community. Major increasers are buffalograss and Texas wintergrass. Plants that commonly invade are red grama, mesquite, pricklypear, and annual grasses and weeds.

In favorable years herbage yield is 2,500 pounds per acre. In unfavorable years it is 1,300 pounds per acre.

Deep Sand range site

This site is made up of deep, sandy soils. The sand allows rapid water intake and deep penetration. Consequently, the amount of runoff is small and evaporation loss is low. Little water is available to shallow-rooted plants, but deep-rooted, perennial grasses grow well. Soil blowing is a hazard if vegetation is removed.

Range seeding is needed in overgrazed areas and in some areas of abandoned cropland. Starting new plants is difficult. The plants are likely to be covered with drifting sand or cut off by blowing sand. In places the sand dries out so fast that seedling roots do not get enough moisture.

Decreaser grasses in the potential plant community are giant dropseed, indiangrass, little bluestem, sand lovegrass, and switchgrass. Increasers are hooded windmillgrass, hairy grama, and sand dropseed. The most common invaders are annual weeds, sandburs, and fringed signalgrass. There are a few motts of Havard oak, post oak, prickly-ash, and hackberry. Forage is of low to medium quality because of the low fertility of the soils.

In favorable years herbage yield is 2,400 pounds per acre. In unfavorable years it is 1,200 pounds per acre.

Loamy Bottomland range site

This is the most productive site in the county. It is made up of nearly level, deep, loamy soils on flood plains. These soils receive floodwater and runoff. The rate of water intake is moderate, and the available water capacity is high. The hazard of erosion is only slight, but floodwater causes minor damage in some low areas and sedimentation during floods temporarily damages

vegetation. Hoofpans and surface crusting are common if the vegetation is removed.

Since settlement, the vegetation on this site has undergone major changes. The site has always been heavily grazed. For many years, streams were the only sources of water in the county and trees that provided shade grew only along streams. The common grasses now are johnsongrass and rescuegrass.

Maintaining a good cover of vegetation through control of mesquite and limitation of grazing helps in controlling runoff, reducing the risk of erosion, and conserving moisture.

The potential plant community is a mixture of grasses, trees, and forbs. Principal decreasers are Canada wildrye, little bluestem, indiangrass, cane bluestem, side-oats grama, bush sunflower, and prairie acacia. Buffalograss, Texas wintergrass, and spiny aster increase if the site is overused. Plants that invade are sand dropseed, three-awn, hooded windmillgrass, rescuegrass, little barley, many species of annual weeds, cactus, mesquite, white brush, and other species of brush. Along the streams are scattered stands of pecan, elm, willow, hackberry, and oak.

In favorable years herbage yield is 4,500 pounds per acre. In unfavorable years it is 2,000 pounds per acre.

Low Stony Hill range site

The soils in this site are nearly level to steep, dark-colored, friable stony clays that are less than 12 inches thick over limestone. During periods of little rainfall, forage production on this site is likely to be higher than on sites that have deeper soils, because runoff from the slopes concentrates in the soil between the stones. Thus, small amounts of rainfall are used effectively. Soil particles and plant roots penetrate deeply into the cracks and crevices of the underlying limestone. The rate of water intake is high, but the total storage capacity is low, so large amounts of water run off. If the site is overgrazed, sheet erosion is a severe hazard. North-facing slopes have lower temperatures, lower evaporation losses, and thus a thicker vegetative cover than south-facing slopes.

For many years the trend in condition class has been downward, mainly because of the decline of decreaser grasses, which cannot maintain themselves under continuous close grazing. Heavy grazing by goats and sheep has reduced or eliminated skunkbush, sumac, kidneywood, Engelmann daisy, sagewort, perennial legumes, and other desirable forbs and shrubs.

Range seeding is generally not needed, because some of the desirable plants are protected and produce seeds around shrubs or stones. If brush control is needed, the brush should be removed in strips or blocks so that some is left to provide habitat for wildlife. Spot seeding following brush control is sometimes highly successful. Control of grazing is the best means of controlling runoff, reducing the risk of erosion, and conserving moisture.

The potential plant community is an oak savanna, that is, a mixture of grasses, forbs, shrubs, and trees. The topography and the vegetation make this site suitable for sheep, goats, deer, and cattle.

Among the decreaser plants in the potential plant community are side-oats grama, little bluestem, green sprangletop, bush sunflower, sagewort, Engelmann daisy and prairie acacia. Increasers are slim tridens, Wrights three-awn, curly mesquite, live oak, and browse plants. Plants that invade the site are hairy tridens, many kinds of annual weeds and grasses, red three-awn, red grama, and juniper. Trees and shrubs such as live oak, sumac, redbud, kidneywood, and shin oak are part of the potential plant community.

In favorable years herbage yield is 1,300 pounds per acre. In unfavorable years it is 1,000 pounds per acre.

Sandstone Hills range site

The one soil in this site is the Latom soil in Cobb-Latom complex. This soil is a gently sloping to steep, brownish fine sandy loam that is less than 20 inches thick over sandstone. It takes up water rapidly but has only a low capacity for storing it. This low storage capacity combined with the steep slopes results in much runoff. Sandstone outcrops and boulders are common. If this site is overgrazed, there is much soil blowing and water erosion.

Brush control and seeding generally are not needed. Deferment of grazing allows seed to form and seedlings to grow. Range improvement is rapid under light grazing and deferments.

Decreasers are side-oats grama, blue grama, cottontop, and small amounts of sand bluestem. Increasers are hooded windmillgrass, sand dropseed, Reverchon panicum, and perennial three-awn. Invaders are Texas grama, sandbur, annual weeds, cactus, and juniper. Some post oak and live oak are part of the potential plant community.

In favorable years herbage yield is 1,000 pounds per acre. In unfavorable years it is 500 pounds per acre.

Sandy Loam range site

Soils in this site have a surface layer of fine sandy loam, are moderately deep to deep, and range from nearly level to sloping. The surface layer has a high water intake and a low storage capacity; thus, even a small amount of rainfall penetrates deeply and is utilized effectively. The subsoil has slower intake and high storage capacity. If vegetation is removed by overgrazing, soil material is rapidly lost through blowing and water erosion.

The potential plant community is a mixture of grass and scattered post oak and live oak trees. Decreaser plants are side-oats grama, cane bluestem, Arizona cottontop, and little bluestem. Increasers are hooded windmillgrass, buffalograss, hairy grama, three-awn, and sand dropseed. The most common invaders are red grama, Texas grama, gummy lovegrass, annual weeds and grasses, mesquite, cactus, condalia, and catclaw acacia.

In favorable years herbage yield is 2,500 pounds per acre. In unfavorable years it is 1,500 pounds per acre.

Shallow range site

Soils in this site are shallow, firm, and nearly level to moderately steep. They take up water at a moderate rate and have only a moderate storage capacity. The limited storage capacity and the limited depth of the root zone restrict the kinds and amounts of plants that are grown.

This site deteriorates rapidly if it is overgrazed, and it recovers very slowly, even under good management. It supports a thin stand of grasses and forbs.

The potential plant community is made up of side-oats grama, green sprangletop, pinhole bluestem, and a small amount of little bluestem. These species normally decrease under heavy grazing. Increasers are slim tridens, fall witchgrass, hairy grama, and buffalograss. Plants that commonly invade the site are red grama, hairy tridens, red three-awn, annual weeds, condalia, agrito, catclaw acacia, and mesquite. Perennial forbs, such as Engelmann daisy, gaura, dotted gayfeather, evening primrose, and Riddell dozedaisy, are a part of the potential plant community.

In favorable years herbage yield is 1,800 pounds per acre. In unfavorable years it is 1,000 pounds per acre.

Shallow Redland range site

The soils in this site are nearly level to steep, reddish-brown clays and clay loams that are shallow over red marine clays or clay loams. The rate of water intake is slow to moderate. Runoff after heavy rains causes these clayey soils to erode and seal over. If vegetation is removed, gully and sheet erosion are serious hazards. An adequate vegetative cover should be maintained at all times. This is one of the less productive sites in the county.

Decreaser grasses in the potential plant community are side-oats grama, green sprangletop, and Arizona cottontop. Increasers are curly mesquite, hairy grama, Reverchon panicum, and slim tridens. Invaders are red grama, hairy tridens, annual weeds, and a small amount of cactus, mesquite, and juniper.

In favorable years herbage yield is 1,400 pounds per acre. In unfavorable years it is 700 pounds per acre.

Steep Rocky range site

Rough stony land makes up this site. It is rough and stony, very steep, and very shallow. The water-storage capacity is very low, and runoff is rapid. A vigorous stand of vegetation is needed for control of erosion. Small amounts of rainfall are utilized effectively because of the stony surface; water runs off the stones and concentrates in the soil between the stones. North-facing slopes have lower temperatures, lower evaporation losses, and thus a thicker vegetative cover than south-facing slopes.

A downward trend in range condition is typical on those ranches where goats and sheep overgraze the vegetation. This steep, rough site is better suited to goats and sheep than to cattle.

Decreaser plants are little bluestem, tall grama, green sprangletop, side-oats grama, and Canada wildrye. Forbs, such as gaura, sagewort, and bush sunflower, decrease if the site is overused by sheep or goats. Plants that increase are slim tridens, perennial three-awn, and fall witchgrass. Live oak, sumac, hackberry, and juniper are native to this site, and grow mainly in draws and headers. Plants that invade are annual weeds, red grama, and pricklypear.

In favorable years herbage yield is 1,000 pounds per acre. In unfavorable years it is 600 pounds per acre.

Very Shallow range site

This site is made up of gently sloping to moderately steep, grayish-brown, calcareous soils that are less than 10 inches thick over caliche or limestone. Runoff is rapid if vegetation is removed. The rate of water intake is high, but the total storage capacity is low.

The potential plant community is a prairie of grasses and forbs. The major decreasers are side-oats grama, green sprangletop, tall grama, and colonies of little bluestem and indiangrass in areas of fractured rock. Increasers are curly mesquite, slim tridens, fall witchgrass, and perennial three-awns. The most common invaders are red grama, hairy tridens, annual weeds, cactus, catclaw acacia, and juniper. Forbs make up an important part of the potential vegetation. Among these are orange zexmenia, bush sunflower, plains dozedaisy, gaura, and evening primrose. They decrease if the site is overgrazed by sheep.

In favorable years herbage yield is 900 pounds per acre. In unfavorable years it is 500 pounds per acre.

Use of the Soils for Wildlife

Wildlife is not abundant in Runnels County. The best soils for growing food and cover are under cultivation, and the soils not suitable for cultivation are overgrazed by livestock. The amount of water carried by streams is decreasing, and the water is polluted. In this county the most common pollutant is not industrial waste and chemicals, but sediments from eroding soils.

In spite of these adverse factors, many areas in the county can be managed so that they provide an adequate supply of food and clear water for wildlife and additional cover for protection from weather and enemies.

Ponds and areas around ponds provide good habitat. Soil features that affect the suitability of each soil in the county for a farm pond is shown in table 4, page 44, in the section "Use of the Soils in Engineering." The features considered in this table are seepage, stability, and ease of excavation. Ponds are much improved in quality of water and for use as wildlife sites if they are fenced off, to exclude livestock. Nearby plantings of grain sorghum or millet attract waterfowl. Water for livestock can be piped from the pond to a trough outside the fenced-in area.

Management of Wildlife by Soil Associations

The soils of the county are grouped into four wildlife sites. The soils in each site are similar in topography, in water supply, in kind and amount of vegetation, and in abundance and species of wildlife. Each species has unique requirements for food, cover, shelter, and space. The soils of a particular site might provide good habitat for some species but very poor habitat for others.

The wildlife sites in this county are described, by soil associations, in the paragraphs that follow. Each soil association is described under the heading "General Soil Map," and its location is shown on the general soil map at the back of this publication.

Wildlife site 1

This site is made up of soil associations 1 and 7. It is a fairly open upland prairie covered with low brushy vegetation. The soils are deep to very shallow. The native plants that are especially attractive to wildlife are catclaw, cedar, littleleaf sumac, agrito, condalia, mesquite trees, gaura, bush sunflower, zexmenia, croton, plains dozedaisy, ragweed, filaree, indiangrass, plains bristlegrass, cactus, and panicum. Among the wildlife species that use this site are bobwhite quail, scaled quail, mourning doves, rabbits, and many small mammals and birds.

This site can be improved by establishing food and cover plants around watering places. Tobosa, Valera, Mereta, and Portales soils, which are the deeper soils of this site, are to be preferred for such plantings. Bumelia and hackberry are native trees that provide shelter, edible seeds, and nesting sites. They can be planted in small depressions where runoff accumulates, if there are no available sites along the water. Fence-row food strips can be provided by leaving unharvested grain or by planting crops that grow in winter, when trees are dormant. A strip 8 feet wide and 1 mile long takes up less than an acre. Suitable seed-producing crops are johnsongrass, grain sorghum, sunflower, millet, croton, oats, barley, and wheat. The soils most suitable for these crops are those that can be cultivated with the least risk of erosion, for example, the nearly level parts of the Portales, Mereta, Kavett, Tobosa, and Valera soils.

Quail need overhead cover for feeding and traveling, tangled cover for escape, and open ground with a dense overhead cover for resting and dusting. Mesquite trees, which are well distributed on all of the deeper soils, provide good cover. If the lower limbs of mesquite trees are cut in such a way that they bend to the ground but are not removed from the trees, they form a living fence, which discourages grazing and protects the needed cover of forbs and grasses. This practice is called "half cutting."

Wildlife site 2

This site is made up of soil associations 2 and 4. It is mainly cropland but includes some rangeland and many intermittent lakes. It is on uplands. The soils are mostly deep and nearly level to gently sloping. Most of the acreage is cultivated, and much of the wildlife food is waste grain. Among the food and cover plants in fence rows and on rangeland are johnsongrass, sunflower, panicum, plains bristlegrass, rescuegrass, cactus, catclaw, gaura, mesquite trees, ragweed, and croton. The wildlife species that use this site are mourning doves, bobwhite quail, scaled quail, rabbits, and many small birds.

Especially important to wildlife on this site are fence-row plantings or unharvested grain, preservation of food- and cover-producing shrubs and trees, and half cutting of mesquite trees, which is described under the heading "Wildlife site 1." Grassed waterways (fig. 15) are valuable for wildlife because they provide cover in otherwise open cropland. Areas of Lipan clay, which are intermittently ponded, can be improved as waterfowl habitat. Pits dug to provide areas of open water that last for longer periods and nearby plantings of grain sorghum or millet, which are choice foods, would make these areas attractive to ducks. These foods must be covered with water to be readily available to ducks.

Wildlife site 3

This site is made up of soil associations 5 and 6. It is the roughest landscape in the county, and the soils are mostly very shallow. This site has a moderate to heavy stand of woody vegetation that includes a wide variety of browse plants. It also has a wide variety of grasses and forbs. The wildlife that use this site are white-tailed deer, turkeys, squirrels, rabbits, bobwhite quail, scaled quail, mourning doves, and many small mammals and birds. In recent years the number of deer and turkeys has increased.

Some of the native plants important to wildlife are the mast-producing post oak, live oak, and shin oak, and the evergreen cedars. Other food and cover plants are catclaw, littleleaf sumac, flameleaf sumac, skunkbush sumac, condalia, agrito, redbud, kidneywood, cactus, and mesquite. Native forbs are sunflower, zexmenia, gaura, white pricklepoppy, evening primrose, ragweed, Engelmann daisy, dotted gayfeather, and croton. Some of the larger seeded grasses are plains bristlegrass, rescuegrass, panicum, johnsongrass, and hooded windmillgrass.

This site is a favored habitat of deer. Deer browse on woody plants and graze many forbs, but they do not eat grass unless it is green and tender. They prefer to stay near woody cover, even when feeding in open areas, and to bed down during the day in motts or thickets of brush. The habitat can be improved by providing winter foods, for example, fall-planted oats, wheat, rescuegrass, and clover, in well-distributed small fields. Favorite foods in summer are grain sorghum, alfalfa, and peanuts. The soils most suitable for these crops are the nearly level soils that can be cultivated with the least risk of erosion, and the deeper soils that produce the most seed and forage, for example, parts of the Cobb, Winters, and Karnes soils. Dense wooded areas can be improved by thinning in patterns that leave both brushy and open areas. Woody plants can be left along drainageways and on the rough stony parts of this site. Den trees for squirrels and predators should never be destroyed.

Turkeys roam widely. They must have water daily, and they will leave any area if water is unavailable during droughts. They also need tall trees for roosting. A nesting hen needs dense ground cover, and water must be within 400 feet. Hence, the habitat can be greatly improved by excluding livestock from small plots near watering places and by curtailing all activity around these areas during the nesting season. Food plantings that benefit deer also benefit turkeys. Groves of tall trees along drainageways are good roosting sites.

Wildlife site 4

This site is soil association 3, which is mostly bottom land. The natural vegetation is a mixture of grasses, trees, and forbs. Some areas have pecan, elm, willow, hackberry, bumelia, oak, mesquite, and western soapberry, in addition to many of the forbs and grasses that grow on wildlife site 3. Wildlife that use this site are turkey, bobwhite quail, scaled quail, mourning doves,

Figure 15.—**K. R. bluestem seeded in waterway on Portales clay loam.**

squirrels, rabbits, a few deer, and many small mammals and birds.

Preservation of food-producing shrubs and trees and den trees for squirrels and predators is most important to the wildlife on this site. The fenced plots and the food plantings mentioned in the description of wildlife site 3 are also applicable to this site. The best sites for plantings are the deep, nearly level soils that are not subject to damaging overflow, for example, parts of the Spur, Colorado, Yahola, Miles, Winters, Olton, and Acuff soils.

Use of the Soils as Recreational Areas

Table 4, page 44, in the section "Use of the Soils in Engineering," can be used as a general guide in selecting sites for recreational activities. This table gives the degree and kind of limitation of each soil in the county for use as campsites, picnic areas, and intensive play areas. The limitations are based on soil characteristics. Esthetic factors that affect the desirability of the site, such as the number of trees or lakes, were not considered. Some soils that have severe limitations are in scenic locations, but these soils would require extensive preparation and maintenance. Also, some soils that have slight or no limitations are covered with noxious weeds or lack shade trees, grass plantings, or water developments.

The column headed "Campsites" in table 4 refers to tent and trailer sites and the accompanying activities for outdoor living. The site should require little preparation. It should be suitable for unsurfaced parking for cars and camp trailers and for heavy traffic by humans, horses, or vehicles. The most suitable sites are free of stones and rock outcrops, have gentle slopes and good drainage, and are not subject to flooding. Information in the column "Road fill" will be useful in determining the suitability of soils for areas subject to intense traffic.

The limitations of the soils for picnic sites are like those for campsites, except that for picnic sites the slopes can be somewhat steeper and an occasional flood is less hazardous. Very stony or rocky soils are unsuitable. Also unsuitable are wet clayey soils and dry sandy soils, both of which create traffic problems.

330-435—70——4

Areas used for playgrounds and organized games like baseball and football are subject to heavy foot traffic. The soils selected should be nearly level, have good drainage, and have a firm surface. They should be free of gravel, stones, and outcrops and should be suitable for the establishment of a vegetative cover where needed.

Use of the Soils in Engineering[2]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, facilities for water storage, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to engineers are permeability, shear strength, compaction characteristics, drainage, shrink-swell characteristics, available water capacity, particle size, plasticity, and reaction. Depth to the water table, depth to bedrock, and topography also are important.

The information in this publication can be used to—

1. Make studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make preliminary estimates of the engineering properties of soils in planning farm ponds, irri-

[2] This section by WILLIAM R. EVANS, area engineer, Soil Conservation Service, San Angelo, Texas.

TABLE 3.—*Estimated*

[Properties were not determined for

Soil series and map symbols	Depth from surface	Classification: Dominant USDA texture
	In.	
Acuff: AcA, AcB.	0–12	Loam
	12–24	Sandy clay loam
	24–38	Sandy clay loam
	38–60	Sandy clay loam
Badland.		
Brownfield.	0–24	Fine sand
	24–70	Sandy clay loam
Cobb: Cl, CwA, CwB, CwC.	0–18	Fine sandy loam
For Latom part of Cl, see Latom series.	18–36	Sandy clay loam
For Winters part of CwA, CwB, and CwC, see Winters series.	36	Sandstone.
Colorado: Cy.	0–16	Loam
For Yahola part of Cy, see Yahola series.	16–60	Mainly loam; stratified with fine sandy loam and clay loam.
Karnes: KaC.	0–12	Fine sandy loam
	12–60	Sandy clay loam
Kavett: KvA, KvB.	0–16	Silty clay
	16	Limestone.
Latom.	0–8	Fine sandy loam
	8	Sandstone.
Lipan: Lc.	0–62	Clay
Mereta: McA, McB.	0–19	Clay loam
	19–24	Cemented caliche.
	24–40	Caliche (clay loam)
Miles:		
MfA, MfB.	0–8	Fine sandy loam
	8–60	Sandy clay loam
	60–65	Sandy clay loam
MlB.	0–14	Loamy fine sand
	14–66	Sandy clay loam
Olton: OcA, OcB.	0–18	Clay loam
	18–41	Clay
	41–70	Silty clay loam, clay loam

gation systems, or other structures for conservation of soil and water.
3. Make preliminary evaluations that will aid in selecting locations for highways, airports, pipelines, and other engineering structures, and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel and sand and other construction material.
5. Correlate performance with soil mapping units to develop information that will be useful in planning engineering practices and in designing and maintaining engineering structures.
6. Determine the suitability of soils for cross-country movement of vehicles and construction equipment.
7. Supplement other publications, such as maps, reports, and aerial photographs, that are used in preparation of engineering reports for a specific area.

With the soil map for identification of soil areas, the engineering interpretations reported in tables 3, 4, and 5 can be useful for many purposes. It should be emphasized, however, that these interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and excavations deeper than the depth of layers here reported.

engineering properties

Badland and Rough stony land]

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
					In./hr.	*In./in. of soil*	
ML-CL	A-4	------------	100	60–75	0. 8–1. 5	0. 15	Low to moderate.
SC	A-6	------------	100	35–50		. 13	Low to moderate.
CL or SC	A-6	------------	100	45–60		. 13	Moderate.
SC	A-6	100	75–85	35–50		. 13	Low to moderate.
SP or SM	A-2	100	95–100	5–10	5. 0–10. 0	. 05	Low.
SC	A-4	------------	100	35–50	0. 8–2. 5	. 12	Moderate.
SM or SC	A-4	------------	100	35–50	0. 8–2. 5	. 066	Low.
SC	A-6	------------	100	35–50		. 117	Moderate.
ML-CL	A-4	------------	100	60–75	0. 8–2. 5	. 15	Low.
SC or CL	A-4	------------	100	40–55	1. 5–2. 0	. 07	Low.
SC or CL	A-6	100	90–100	40–55		. 12	Moderate.
CL or CH	A-7	90–100	90–100	75–95	0. 8–2. 5	. 18	High.
SM	A-4	100	95–100	35–40	0. 8–2. 5	. 12	Low.
CH	A-7	100	95–100	85–95	0. 05–0. 2	. 8	High.
CL	A-7	95–100	90–100	65–80	0. 8–2. 5	. 18	Moderate.
CL	A-6	100	80–100	50–70		. 14	Moderate.
SC or ML	A-4	100	90–100	40–55	0. 8–1. 5	. 125	Low.
SC or CL	A-6	100	90–100	40–55		. 14	Low to moderate.
SC or CL	A-6	95–100	95–100	40–55		. 10	Low to moderate.
SM	A-2	95–100	90–100	15–35	0. 8–2. 5	. 09	Low.
SC or CL	A-4	95–100	90–100	40–55		. 14	Low to moderate.
CL or CH	A-7	90–100	80–90	70–85	0. 8–1. 5	. 18	Moderate.
CL	A-7	85–100	75–100	75–95		. 17	Moderate.
CL	A-6	80–100	75–100	55–95		. 15	Moderate.

TABLE 3.—*Estimated engineering*

Soil series and map symbols	Depth from surface	Classification
		Dominant USDA texture
	In.	
Portales: PoA, PoB.	0–28	Clay loam
	28–60	Clay loam
Potter: Pt.	0–6	Clay loam
	6–15	Platy caliche.
	15–36	Caliche
Rough stony land: Ro.		
Rowena: RtA, RtB. For Tobosa part of RtA and RtB, see Tobosa series.	0–18	Clay loam
	18–37	Clay
	37–49	Silty clay loam
	49–60	Clay loam
Spur: Sp.	0–84	Loam
Stamford: StA, StB.	0–54	Clay
Talpa: Tk. For Kavett part of Tk, see Kavett series.	0–7	Clay loam
	7–10	Limestone fragments.
Tarrant: TrC, TrD.	0–9	Clay
	9–12	Limestone fragments and clay.
	12	Limestone.
Tivoli: Tv, Tw. For Brownfield part of Tw, see Brownfield series.	0–60	Fine sand
Tobosa: TyA, TyB.	0–80	Clay
Valera: VaA, VaB.	0–24	Silty clay
	24–30	Silty clay
	30–60	Clay or marl stratified with limestone.
Vernon: Vb. Properties not determined for Badland part of Vb.	0–18	Clay
	18–60	Shaly clay.
Weymouth: WeB.	0–16	Clay loam
	16–24	Silty clay loam
	24–40	Silty clay loam
Winters: WnA, WnB, WnB2.	0–10	Fine sandy loam
	10–50	Sandy clay
	50–70	Clay loam
Yahola: Ya.	0–62	Fine sandy loam

properties—Continued

Classification—Continued		Percentage passing sieve—			Permea-bility	Available water capacity	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
					In./hr.	*In./in. of soil*	
CL	A-7	100	90-100	65-80	1. 0-1. 5	. 18	Moderate.
CL	A-6	100	80-100	50-70		. 15	Moderate.
CL	A-6	90-100	80-95	60-80	0. 8-2. 5	. 16	Moderate.
CL	A-6	100	80-100	50-70		. 14	Moderate.
CL	A-6	------------	100	70-80	0. 2-0. 8	. 18	Moderate.
CL or CH	A-7	100	95-100	80-90		. 18	Moderate to high.
CL	A-6	80-100	70-100	50-85		. 16	Moderate.
CL	A-6	90-100	70-100	50-80		. 14	Moderate.
CL	A-6	95-100	95-100	70-90	0. 8-2. 5	. 15	Moderate.
CH	A-7	95-100	95-100	85-95	0. 5-0. 2	. 15	High.
CH	A-7	100	90-100	70-80	0. 2-0. 8	. 15	Moderate.
CH or GC	A-7, A-2	60-80	35-65	25-55	0. 2-0. 8	. 18	High.
SP or SM	A-3	100	95-100	5-10	2. 5-5. 0	. 05	Low.
CH	A-7	95-100	95-100	90-100	0. 2-0. 5	. 20	High.
CH	A-7	100	90-100	80-95	0. 8-1. 5	. 20	High.
CL	A-6	75-95	70-90	60-85		. 18	Moderate.
CH	A-7	100	85-95	75-85	0. 05-0. 2	. 15	High.
CL	A-7	100	90-100	75-85	0. 8-1. 5	. 17	Moderate.
CL	A-6	100	85-95	60-80		. 15	Moderate.
CL	A-7	100	95-100	75-85		. 05	Moderate.
SM	A-4, A-2	100	90-100	30-50	1. 5-2. 5	. 066	Low.
SC	A-6, A-2	100	90-100	30-50		. 12	Low to moderate.
SC	A-6	100	80-90	35-50		. 12	Moderate.
SM	A-4	100	90-100	40-50	1. 5-2. 5	. 14	Low.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—			
	Topsoil	Road fill	Highway location[1]	Farm ponds: Reservoir area	Farm ponds: Embankment	Irrigation
Acuff: AcA, AcB	Good	Fair	Fair stability; eroson hazard on exposed embankments.	Moderate permeability; waterworn gravel at a depth of 30 inches.	Fair stability; fair compaction; low compressibility.	No limiting features.
Badland	Poor	Very poor	Poor stability; severe erosion hazard on exposed embankments.	No limiting features.	Clayey material; high volume change; poor compaction; high compressibility.	Not applicable
Brownfield	Poor	Fair to good.	Dune topography; hazard of soil blowing.	Excessive seepage.	Fair stability in subsoil.	Very high intake; low available water capacity.
Cobb: Cl, CwA, CwB, CwC. For Latom part of Cl, see Latom series. For Winters part of CwA, CwB, and CwC, see Winters series.	Fair	Good	Outcrops of sandstone and conglomerate; severe erosion hazard on exposed embankments.	Moderate permeability in sandstone or conglomerate substratum.	Fair stability	Moderate available water capacity.
Colorado: Cy. For Yahola part of Cy, see Yahola series.	Good	Fair	Frequent flooding; fair stability.	Moderate permeability; siltation during overflow.	Fair stability; fair compaction; fair resistance to piping.	Undulating topography; frequent flooding.
Karnes: KaC	Fair	Fair to good.	Severe erosion hazard; undulating topography.	Moderate permeability.	Fair stability; severe erosion hazard; slopes unstable unless protected.	Steep slopes; hazard of water erosion.
Kavett: KvA, KvB	Fair	Very poor	Limestone at a depth of 6 to 16 inches.	Limestone at a depth of 6 to 16 inches.	Fair to poor stability; limited fill material.	Shallow over limestone.
Latom	Fair	Fair	Sandstone at a depth of less than 1 foot.	Less than 1 foot to sandstone.	Limited fill material.	Low available water capacity; shallow over sandstone.
Lipan: Lc	Poor	Very poor	Poor stability; high plasticity; flood hazard.	No limiting features.	Clayey material; high volume change; poor stability.	Flood hazard
Mereta: McA, McB	Good	Poor	High plasticity; shallow over cemented caliche.	Moderate permeability; cemented caliche at a depth of 10 to 20 inches.	Fair stability; medium to high compressibility.	Wavy substratum; shallowness affects land leveling.

interpretations

Soil features affecting—Continued			Degree and kind of limitation for—			
Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Campsites	Picnic areas	Intensive play areas	Sewage disposal
No limiting features.	No limiting features	Fair bearing capacity; low to moderate shrink-well potential.	Slight	Slight	Slight	Moderate: moderate permeability.
Not applicable	Not applicable	High shrink-swell potential; poor internal drainage; poor shear strength.	Severe: clay texture.	Severe: clay texture.	Severe: clay texture.	Severe: very slow permeability.
Dune topography; severe hazard of soil blowing; difficult to vegetate.	Severe erosion hazard; difficult to vegetate.	Dune topography; poor stability, but good if confined.	Moderate: sand texture.	Moderate: sa d texture.	Moderate: sand texture.	Moderate: dune topography.
Coarse-textured material; hazard of soil blowing.	Slight erosion hazard; difficult to vegetate.	Sandstone or conglomerate below a depth of 3 feet; some outcrops.	Slight	Slight	Severe: 0 to 5 percent slopes; depth to rock less than 4 feet.	Moderate: sandstone or conglomerate within a depth of 4 feet.
Not applicable	Not applicable	Frequent flooding	Severe: flood hazard.	Moderate: flood hazard.	Severe: flood hazard.	Severe: frequent flooding.
Severe erosion hazard; difficult to vegetate.	Severe erosion hazard; steep slopes; difficult to vegetate.	Fair shear strength.	Slight to moderate: 2 to 10 percent slopes.	Slight to moderate: 2 to 10 percent slopes.	Severe: 2 to 10 percent slopes.	Moderate: 2 to 10 percent slopes.
Limestone at a depth of 6 to 16 inches.	Slight erosion hazard; difficult to vegetate; limestone at a depth of 6 to 16 inches.	Fair bearing capacity; high shrink-swell potential; limestone at a depth of 6 to 16 inches.	Severe: clay texture.	Severe: clay texture.	Severe: less than 20 inches to limestone.	Severe: less than 2 feet to limestone.
Sandstone within cutting depth; severe erosion hazard.	Shallow over sandstone; difficult to vegetate.	Dense sandstone at a depth of less than 1 foot.	Severe: rockiness.	Moderate: rockiness.	Severe: less than 1 foot to sandstone.	Severe: less than 1 foot to sandstone.
Slow permeability; no available outlets; surface cracks when dry.	Not applicable	Poor shear strength; poor internal drainage; flood hazard.	Severe: ponding hazard; clay texture.	Severe: ponding hazard; clay texture.	Severe: hazard of ponding; clay texture.	Severe: slow permeability.
Cemented caliche at a depth of 10 to 20 inches.	Cemented caliche exposed in deep cuts; low available water capacity; difficult to vegetate.	Fair bearing capacity; moderate shrink-swell potential.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	Severe: cemented caliche below a depth of 10 to 20 inches.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—			
	Topsoil	Road fill	Highway location [1]	Farm ponds: Reservoir area	Farm ponds: Embankment	Irrigation
Miles: MfA, MfB, MlB	Fair	Good	Fair stability; hazards of soil blowing and water erosion.	Moderate permeability.	Fair stability; fair compaction; piping hazard.	Moderate available water capacity; hazards of blowing and water erosion.
Olton: OcA, OcB	Fair	Poor	High plasticity	Moderately slow permeability; amount of waterworn gravel increases with increasing depth.	Fair stability; fair compaction; medium to high compressibility.	Waterworn gravel on surface and throughout profile.
Portales: PoA, PoB	Good	Poor	Fair stability; fair bearing capacity.	Moderate permeability; excessive seepage.	Fair stability; fair compaction; high compressibility.	Conditioning needed after leveling in heavy cut areas.
Potter: Pt	Fair	Poor	Fair stability; fair bearing capacity; steep slopes.	Excessive seepage; caliche at a depth of 4 to 12 inches.	Fair stability; fair compaction.	Not applicable
Rough stony land: Ro	Not suitable.	Very poor	Large boulders; steep slopes.	Very shallow over bedrock.	Not applicable	Not applicable
Rowena: RtA, RtB. For Tobosa part of RtA and RtB, see Tobosa series.	Good	Poor	Fair stability; plasticity.	No limiting features.	Fair stability; fair compaction; high volume change.	Conditioning needed in heavy cut areas after leveling.
Spur: Sp	Good	Poor	Occasional flooding; fair stability; plasticity.	Moderate permeability.	Fair stability; high compressibility.	Occasional flooding; moderate permeability.
Stamford: StA, StB	Poor	Very poor	Poor stability; high plasticity.	No limiting features.	Poor stability; high volume change; poor compaction.	No limiting features.
Talpa: Tk. For Kavett part of Tk, see Kavett series.	Fair	Very poor	Limestone at a depth of 4 to 10 inches.	Limestone at a depth of 4 to 10 inches.	Fair to poor stability; limited fill material.	Not applicable
Tarrant: TrC, TrD	Fair	Very poor	Limestone at a depth of 4 to 12 inches.	Limestone at a depth of 4 to 12 inches.	Poor stability; limited fill material.	Not applicable

interpretations—Continued

Soil features affecting—Continued			Degree and kind of limitation for—			
Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Campsites	Picnic areas	Intensive play areas	Sewage disposal
Sandy material; hazards of soil blowing and water erosion.	Sandy material; severe erosion hazard.	Fair shear strength; fair resistance to piping.	None to slight	None to slight	None to slight	No limitations.
Spots of gravelly surface material.	Dense clayey material exposed in deep cuts; gravelly throughout profile.	Fair bearing capacity; moderate shrink-swell potential; fair shear strength.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	Slight: few limitations.
No limiting features.	No limiting features.	Fair stability; moderate to high shrink-swell potential; fair shear strength.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	No limitations.
Construction difficult where slopes exceed 12 percent.	Steep slopes; shallow over caliche; difficult to vegetate.	Fair bearing capacity; fair shear strength.	Slight to moderate: slopes.	Slight to moderate: slopes.	Moderate to severe: slopes; gravel content.	Severe: steep slopes.
Not applicable	Not applicable	Limestone bedrock on surface.	Severe: slopes more than 25 percent; stoniness.	Severe: slopes more than 25 percent; stoniness.	Severe: slopes more than 25 percent; depth to bedrock less than 3 inches.	Severe: steep slopes; shallowness.
No limiting features.	No limiting features.	Fair bearing capacity; high shrink-swell potential; fair shear strength.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture.	Severe: moderately slow permeability.
Occasional flooding.	Occasional flooding.	Fair bearing capacity; moderate to high shrink-swell potential; occasional flooding.	Severe: flood hazard.	Moderate: flood hazard.	Severe: flood hazard.	Severe: occasional flooding.
Slow permeability; surface cracks when dry; poor stability.	Dense clay material; difficult to vegetate; rapid runoff.	Poor shear strength; high shrink-swell potential; poor internal drainage.	Severe: clay texture.	Severe: clay texture.	Severe: clay texture.	Severe: slow permeability.
Limestone at a depth of 4 to 10 inches.	Steep slopes; limestone at a depth of 4 to 10 inches.	Limestone at a depth of 4 to 10 inches.	Moderate: clay loam texture.	Moderate: clay loam texture.	Severe: less than 10 inches to limestone.	Severe: less than 10 inches to limestone.
Limestone at a depth of 4 to 12 inches.	Steep slopes; limestone at a depth of 4 to 12 inches.	Limestone at a depth of 4 to 12 inches.	Severe: clay texture; slopes; stoniness.	Severe: clay texture; slopes; stoniness.	Severe: less than 1 foot to limestone; clay texture.	Severe: less than 1 foot to limestone.

TABLE 4.—*Engineering*

Soil series and map symbols	Suitability as source of—		Soil features affecting—			
	Topsoil	Road fill	Highway location[1]	Farm ponds: Reservoir area	Farm ponds: Embankment	Irrigation
Tivoli: Tv, Tw. For Brownfield part of Tw, see Brownfield series.	Poor	Fair	Dune topography; hazard of soil blowing.	Excessive seepage.	Sandy material; rapid seepage; difficult to vegetate.	Very high intake; low available water capacity.
Tobosa: TyA, TyB	Poor	Very poor	Poor stability; poor shear strength; high shrink-swell potential.	No limiting features.	Poor stability; poor compaction; high volume change.	No limiting features.
Valera: VaA, VaB	Poor	Very poor	Poor stability; limestone at a depth of 20 to 40 inches.	Moderately slow permeability; limestone at a depth of 20 to 40 inches.	Poor stability; poor compaction; high compressibility.	Limestone at a depth of 20 to 40 inches.
Vernon: Vb. For Badland part of Vb, see Badland.	Poor	Very poor	Poor stability; severe erosion hazard on exposed embankments.	No limiting features.	Poor stability; poor compaction; high compressibility.	Not applicable.
Weymouth: WeB	Poor	Poor	High plasticity	No limiting features.	Fair stability; fair compaction; medium to high compressibility.	Waterworn gravel on surface and to a depth of 16 inches.
Winters: WnA, WnB, WnB2	Fair	Fair	Severe erosion hazard on exposed embankments.	Sandstone or conglomerate in substratum in some areas.	Fair stability; fair compaction; severe erosion hazard; difficult to vegetate.	Moderately slow intake; severe erosion hazard.
Yahola: Ya	Fair	Good	Fair stability; fair to good compaction; occasional flooding.	Moderately rapid permeability.	Fair stability; fair resistance to piping.	Moderately high intake; occasional flooding.

[1] Engineers and others should not apply specific values to the estimates of bearing capacity of soils.

interpretations—Continued

Soil features affecting—Continued			Degree and kind of limitation for—			
Terraces and diversions	Grassed waterways	Foundations for low buildings [1]	Campsites	Picnic areas	Intensive play areas	Sewage disposal
Dune topography; severe hazard of soil blowing; difficult to vegetate.	Severe erosion hazard; difficult to vegetate.	Dune topography; poor stability, but good if confined.	Severe: hazard of soil blowing.	Severe: hazard of soil blowing.	Severe: hazard of soil blowing.	Moderate: dune topography; contamination potential.
Slow permeability; surface cracks when dry.	Dense clay; difficult to vegetate; rapid runoff.	Poor shear strength; high shrink-swell potential; poor internal drainage.	Severe: clay texture.	Severe: clay texture.	Severe: clay texture.	Severe: slow permeability.
Limestone at a depth of 20 to 40 inches.	No limiting features.	Poor shear strength; high shrink-swell potential; limestone at a depth of 20 to 40 inches.	Severe: clay texture.	Severe: clay texture.	Severe: clay texture.	Severe: 20 to 40 inches to limestone.
Severe erosion hazard; difficult to vegetate; construction difficult.	Difficult to construct or vegetate; erosion hazard; rapid runoff.	Poor shear strength; high shrink-swell potential.	Severe: clay texture; slopes.	Severe: clay texture; slopes.	Severe: clay texture; slopes.	Severe: slow permeability; steep slopes.
Gravelly surface material.	Gravelly throughout uppermost 16 inches.	Fair bearing capacity; fair shear strength; moderate to high shrink-swell potential.	Moderate: clay loam texture.	Moderate: clay loam texture.	Moderate: clay loam texture; 1 to 3 percent slopes.	Severe: dense clay less than 2 feet below tile floor.
Severe erosion hazard; hazard of excessive siltation in channels; difficult to vegetate.	Sandy material; severe erosion hazard; low available water capacity; difficult to vegetate.	Fair bearing capacity; fair shear strength; moderate to high shrink-swell potential.	None to slight	None to slight	Slight to moderate: moderately slow permeability.	Slight: few limitations.
Occasional flooding; undulating slopes.	Sandy material; erosion hazard.	Occasional flooding.	Severe: flood hazard.	Moderate: flood hazard.	Severe: flood hazard.	Severe: occasional flooding.

TABLE 5.—*Engineering test data for soil*

[Tests performed by Texas State Highway Department in accordance with standard

Soil name and location	Parent material	Texas report number	Depth	Shrinkage		
				Limit	Lineal	Ratio
			In.	*Pct.*	*Pct.*	
Lipan clay:						
0.8 mile east of Miles, 1.3 miles northeast of U.S. Highway 67, and 20 yards north of county road.	Clayey outwash.	62–521–R	6–34	11	20. 4	1. 97
		62–522–R	34–56	13	20. 4	1. 93
0.8 mile northeast of Miles, 1.1 miles north of U.S. Highway 67, and 20 yards west of county road.	Clayey outwash.	62–523–R	8–34	11	20. 4	2. 00
		62–524–R	34–50	10	21. 4	2. 02
Mereta clay loam:						
5.2 miles west of Ballinger and 60 yards south of Texas Highway 158.	Caliche or plains outwash.	62–525–R	8–21	13	14. 0	1. 93
		62–526–R	21–28	17	11. 2	1. 82
15 miles west of Ballinger, 0.6 mile south of Texas Highway 158, and 50 yards west of county road.	Caliche or plains outwash.	62–527–R	9–20	13	11. 5	1. 92
		62–528–R	20–26	17	10. 2	1. 83
Olton clay loam:						
1.6 miles west and 3 miles north of Rowena and 30 yards west of county road.	Old alluvium or plains outwash.	62–537–R	10–18	14	15. 6	1. 97
		62–538–R	31–46	17	9. 7	1. 82
6.4 miles southwest of Ballinger and 30 yards west of farm road 2133.	Old alluvium or plains outwash.	62–539–R	24–31	13	14. 1	1. 92
		62–540–R	41–48	15	10. 0	1. 91
2.5 miles west of Miles, 4.9 miles north of farm road 1692, and 30 yards west of farm road 2333.	Old alluvium or plains outwash.	62–541–R	6–20	10	20. 4	2. 00
		62–542–R	42–56	15	15. 0	1. 88
Rowena clay loam:						
2 miles east and 3 miles south of Rowena and 30 yards south of county road.	Plains outwash.	62–531–R	21–37	11	17. 5	2. 00
		62–532–R	37–49	19	9. 3	1. 74
1 mile north of Miles, 1.8 miles northeast of farm road 1692, and 20 yards west of county road.	Plains outwash.	62–533–R	15–27	10	18. 4	1. 98
		62–534–R	33–40	21	7. 8	1. 71
6.4 miles south of Ballinger, 1 mile east of U.S. Highway 83, and 60 yards south of county road.	Plains outwash.	62–535–R	9–18	11	18. 8	2. 00
		62–536–R	32–44	17	8. 3	1. 85
Spur loam:						
0.2 mile north of Wingate and 30 yards east of farm road 53.	Alluvium (bottomland).	62–519–R	4–27	15	11. 4	1. 87
		62–520–R	27–60	15	9. 3	1. 90

[1] Mechanical analysis according to AASHO Designation: T 88–57. Results by this procedure may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2

samples taken from selected soil profiles

procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [1]											Liquid limit	Plasticity index	Classification	
Percentage passing sieve—								Percentage smaller than—					AASHO	Unified
2-in.	1-in.	¾-in.	⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42) mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.				
											Pct.			
------	------	------	------	------	100	98	93	87	59	51	61	40	A-7-6(20)	CH
------	------	------	------	------	100	98	92	88	61	54	63	42	A-7-6(20)	CH
------	------	------	------	100	99	98	91	86	59	51	60	39	A-7-6(20)	CH
------	------	------	------	------	100	98	91	87	60	52	62	43	A-7-6(20)	CH
------	------	------	100	98	92	84	72	65	42	34	42	25	A-7-6(14)	CL
100	92	88	78	70	61	54	47	43	30	23	40	22	A-6(6)	GC
------	------	------	100	99	96	87	66	59	35	27	36	21	A-6(11)	CL
100	90	85	76	66	57	51	41	38	24	18	38	20	A-6(4)	GC
------	------	------	100	99	98	93	73	65	39	34	48	28	A-7-6(16)	CL
------	------	100	96	92	89	83	73	68	51	38	37	20	A-6(12)	CL
------	------	------	100	99	98	89	64	55	36	33	43	27	A-7-6(13)	CL
------	------	100	96	88	83	76	61	56	37	26	35	19	A-6(9)	CL
------	------	100	99	97	94	90	84	80	54	47	60	40	A-7-6(20)	CH
100	93	93	89	82	75	66	58	55	39	32	48	30	A-7-6(14)	CL
------	------	------	------	------	100	91	82	76	53	45	50	31	A-7-6(18)	CL
------	100	99	99	98	97	91	85	81	62	47	39	18	A-6(11)	CL
------	------	------	------	100	99	91	82	78	51	43	52	33	A-7-6(18)	CH
------	------	100	98	97	95	88	83	79	63	44	36	16	A-6(10)	CL
------	------	------	------	100	99	98	89	82	53	45	54	35	A-7-6(19)	CH
100	98	96	90	83	74	63	53	49	37	24	33	17	A-6(6)	CL
------	------	------	------	------	100	98	84	73	37	32	39	23	A-6(13)	CL
------	------	------	------	------	100	98	72	67	34	28	33	20	A-6(11)	CL

millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analysis data used in this table are not suitable for naming textural classes for soils.

Some of the terms used by soil scientists have a special meaning in soil science that may not be familiar to engineers. These terms are defined in the Glossary.

Engineering Classification Systems

Engineers use two systems for classifying soils. The AASHO system (*1*)[3] was developed by the American Association of State Highway Officials. The Unified system (*8*) is used by the Corps of Engineers, U.S. Army, and by other agencies. Both systems are explained in the PCA Soil Primer (*3*).

Soil scientists use the USDA textural classification (*6*). In this, the texture of the soil is determined according to the proportion of soil particles smaller than 2 millimeters in diameter, that is, the proportion of sand, silt, and clay.

Table 3 shows the estimated classification of all the soils in the county according to all three systems of classification. Table 5 shows the AASHO and Unified classification of specified soils in the county, as determined by laboratory tests.

Estimated Engineering Properties

Estimates of soil properties that are significant in engineering are listed in table 3. The estimates are based on data shown in table 5, on information obtained during the survey, and on experience with the soils of the county and in engineering construction.

The columns headed "Percentage passing sieve—", in table 3, show the percentage of soil material that is smaller in diameter than the openings in the given sieve. Since the estimates are for modal soils, considerable variation in the grain size of any specified soil should be anticipated.

Estimates in the column headed "Permeability" indicate the rate at which water moves through undisturbed soil material. The estimates are based on grain size and distribution, structure, degree of saturation, and degree of compaction, and on comparison with the results obtained from soils previously tested.

In the column head "Available water capacity" are estimates of the amount of water, in inches per inch of soil, that is available to plants. This amount of water, which is the difference between the amount in soil that is wet to field capacity and the amount in the same soil at the wilting point of plants, will wet the soil material described to a depth of 1 inch without deeper percolation.

Shrink-swell potential indicates the volume change to be expected in soil material with a change in moisture content, that is, the extent to which soil shrinks when dry and swells when wet. This potential change is influenced by the amount and kind of clay in the soil. Single-grain soils and soils that contain small amounts of plastic materials have a low shrink-swell potential.

Calcareous soils, which have a pH of 8.0 to 8.5, make up 86 percent of the total acreage in the county. The only noncalcareous soils are Acuff, Brownfield, Cobb, Miles, Olton, and Winters. Brownfield soils have a pH of 6.0 to 7.5; Cobb, Miles, and Winters 6.0 to 8.0; and Acuff and Olton 7.0 to 8.0. No estimates of soil reaction are given in table 3.

The depth to bedrock is more than 60 inches for all but six soil series. The depth for these six series is as follows: Cobb soils, 20 to 48 inches; Kavett soils, 12 to 20 inches; Latom soils, 4 to 20 inches; Talpa soils, 4 to 10 inches; Tarrant soils, 4 to 12 inches; and Valera soils, 20 to 40 inches.

[3] Italic numbers in parentheses refer to Literature Cited, page 59.

Engineering Interpretations

Estimates of the suitability of soils for various engineering uses are given in table 4. Features or characteristics that are likely to affect various engineering practices were considered, and evaluations were based on data shown in table 3 and on field performance.

Soils are given a rating of "poor" or "fair" as a source of topsoil if they are eroded, low in organic-matter content or natural fertility, or clayey and sticky and difficult to handle.

The suitability of a soil for use as road fill depends largely on shear strength, compressibility, workability, shrink-swell potential, bearing capacity, and compaction characteristics. Plastic soils, such as Tobosa clay and Stamford clay, are given a rating of "very poor" because they are difficult to handle if compacted and dried to the desired moisture content. Coarse-textured soils are given a rating of "fair to good" or "fair." These soils have low compressibility and expansion, but they do not have enough binding material and consequently are difficult to place.

No ratings are given in table 4 for the suitability of the soils as a source of sand and gravel. The only sources in the county are isolated areas within a half mile of the Colorado River. Onsite investigation is needed because these areas are not designated on the soil map.

Soil features considered in selecting locations for highways are depth to bedrock, content of stones or boulders, suitability of the soil as a source of embankment material, plasticity, stability of slopes, bearing capacity, susceptibility to frost heave, topography or the need for cuts and fills, and ease of handling and excavation. The water table is low enough so that it does not interfere with highway construction, and there are no organic soils.

The features considered in selecting a site for a pond reservoir are permeability, seepage, flooding, and depth to bedrock.

The features considered in soil material to be used for construction of pond embankments are texture, strength and stability, permeability of compacted material, and shrink-swell potential.

Some of the features considered in evaluating the suitability of a soil for irrigation are soil depth, slope, available water capacity, permeability, and topography.

Features considered significant in the construction of terraces and diversions are depth and stability of the soil material, permeability, topography, and content of stones or rocks.

The suitability of a soil for grassed waterways is determined by the erosion hazard; the amount of shaping that can be done, which in turn depends on slope, stoniness, and depth to bedrock and the difficulty in establishing vegetation.

In the column headed "Foundations for low buildings" are evaluations of the bearing capacity of the substratum for supporting foundations of buildings of less than three stories. The factors considered are shear strength, shrink-swell potential, compressibility, consolidating characteristics, texture, drainage, permeability, and depth to bedrock.

The degrees of limitation of the soils for use as recreational areas are based on flood hazard, permeability, slope, surface texture, depth to bedrock, and stoniness or rockiness.

The degrees of limitation of the soils for use as sewage-disposal fields depends on flood hazard, permeability, slope, depth to bedrock or other impervious material, and the presence of creviced material, which can cause pollution of the water supply. Limiting features in both the soil material and the underlying material were considered.

Engineering Test Data

Soil samples, representing 5 soil series, taken from 11 profiles in the county were tested in accordance with standard procedures to help evaluate the soils for engineering purposes. The tests were made by the Texas State Highway Department. The results are shown in table 5.

Engineering Interpretations by Soil Associations

Important features and characteristics that are typical of large areas of soils and that affect engineering and help in selecting sites suitable for specific engineering structures are described in the following paragraphs by soil associations.

1. Portable-Potter-Mereta association.—Much of this association is underlain by caliche. The soils range from very shallow to deep. The gradient is nearly level to steep.

Shallowness and the underlying caliche are limiting factors for all types of earthen structures. Impounded ponds can be constructed if the basin area and the material used in the foundation of the dam are free of caliche. Otherwise, excessive seepage is likely. The shallow soils are unfavorable sites for terraces, waterways, diversions, and other small surface structures. Constructing terraces on these soils is likely to expose the underlying caliche, and establishing vegetation in waterways is very difficult.

2. Rowena-Tobosa association.—The soil material in this association generally is suitable for earthen structures, such as ponds, terraces, waterways, and diversions. Excavated ponds and impounded ponds ordinarily function satisfactorily, but sealants may be needed to prevent excessive seepage if the soil is calcareous or contains a layer of caliche. The construction of spillways for ponds and of other structures is easier in this area than in other parts of the county. Level, ridge-type terraces that have blocked ends function well. This type terrace needs to be drained during periods of excessive rainfall.

3. Spur-Colorado-Miles association.—This association is near major streams. The part subject to overflow, which is less than half of the total acreage, is recent alluvium. The gradient is nearly level to gently sloping.

There are sources of sand and gravel in this association, but onsite investigation is needed to locate these sources because they are not shown on the soil map. Accumulations of sediments several feet thick occur in most drainageways. In dam construction, considerable seepage is likely to occur unless care is taken in coring across the drain. Most sites except those in overflow areas are suitable for terraces, waterways, and diversions. Deep cuts in leveling should be avoided unless borings are taken before construction to determine the kind of underlying material.

4. Olton-Vernon-Rowena association.—This association has complex drainage and nearly level to moderately steep gradients. The parent material consists mostly of red marine clay and loamy to clayey outwash.

The soils in this association are suitable for excavated ponds, but pond dams are difficult to construct because of the dense clay. The clay has poor stability and poor compaction characteristics, and large cracks are common during periods of dry weather. Spillways tend to erode, and they are difficult to vegetate. Runoff is rapid in most areas. There are suitable sites for terraces, waterways, and diversions. Terraces are used for erosion control as well as for moisture conservation. Waterways and diversions are difficult to stabilize because most of the soils are eroded.

5. Cobb-Winters association.—This association is gently sloping to hilly. The soils have a moderately coarse textured surface layer. The underlying material consists of sandstone and red marine clay. This material is at the surface in some areas.

Excellent sites and soil material for ponds occur in all areas underlain by red marine clay. Areas underlain by sandstone are not suitable, because pond construction is very difficult and seepage, which is generally excessive, cannot be controlled satisfactorily through the use of chemical sealants. Stabilizing spillways is a problem because of the hazards of soil blowing and water erosion, and establishing and maintaining vegetation in spillways and waterways is difficult. Unless controlled, runoff is likely to cause severe damage. Diversions and level, ridge-type terraces provide satisfactory control of erosion if suitable spillways can be constructed to handle excess water. All surface structures are hard to maintain because of the hazard of soil blowing.

6. Tarrant-Rough stony land association.—This association is characterized by steep, hilly, stony soils that are only 4 to 12 inches thick over limestone.

Some areas in this association are possible sources of limestone that is suitable for crushing. The soils are so shallow that, ordinarily, the construction of ponds, terraces, waterways, and diversions is not feasible. Deeper, loamy soils occur at the base of the hills, but they are highly susceptible to erosion because of their slope and texture.

7. Talpa-Kavett association. — This association, which is in the eastern part of the county, is one of low, rolling limestone hills. The soils are 4 to 20 inches thick over limestone.

This association provides sources of limestone that is suitable for crushing. Ponds can be constructed at the base of the hills and along drainageways, but detailed investigation is needed. At some of the sites along drainageways, constructing a pond basin is difficult because the underlying material consists of alternate layers of limestone and yellow marl. Constructing diversions is difficult because of the steep slopes and the shallow soils. Establishing and maintaining vegetation is difficult also.

Formation and Classification of the Soils

This section describes the major factors of soil formation and tells how they have affected the formation of soils in Runnels County. It also shows how the soils of this county have been classified according to the current classification system (7).

Factors of Soil Formation

The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are the active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body with genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be much or little, but some time is always required for horizon differentiation. Usually a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effects of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

The five factors of soil formation as they occur in Runnels County are described in the pages that follow.

Parent material

Parent material is the unconsolidated mass from which a soil forms. It determines the limits of the mineral and chemical composition of the soil.

The parent material in Runnels County consists of shale, clay, marl, limestone, sandstone, and recent alluvium.

Tarrant, Kavett, and Karnes soils formed in material weathered from rocks of the Cretaceous System or in alluvium washed from these formations. Stamford, Vernon, Weymouth, and Olton soils formed in material weathered from shale and red marine clay (fig. 16) of Permian age. Talpa, Kavett, Valera, and Tobosa soils formed in material weathered from limestone and marl of Permian age, and Cobb, Latom, and Winters soils in material weathered from sandstone, conglomerate, and clay of Permain age. Mereta, Miles, Potter, Rowena, Lipan, Tobosa, and Portales soils formed in plains outwash (fig. 17). Spur, Colorado, and Yahola soils formed in recent alluvium, and Brownfield and Tivoli soils in eolian sand blown from alluvium deposited by the Colorado River.

Climate

Climate influences the formation of soils directly through rainfall, temperature, and wind and indirectly through its influence on the amount and kind of vegetation and animal life.

Differences among the soils in this county cannot be attributed to differences in climate alone, because the climate of Runnels County is fairly uniform. The annual precipitation is only about 22 inches. Consequently, there is constant accumulation of mineral nutrients in the soils and underlying material and little or no leaching unless the soil material is sandy.

About 85 percent of the county is made up of soils that are only slightly leached. These soils are calcareous throughout and have a high to fairly high content of plant nutrients. Most have a noticeable accumulation of calcium carbonate, which is relatively soluble and is one of the first materials to be carried downward by water. The depth to the layer of calcium carbonate indicates the depth to which the water moves.

In Mereta clay loam there is a layer of strongly cemented caliche at a depth of about 20 inches (fig. 18). In Portales clay loam, calcium carbonate is diffused throughout the profile but is concentrated at a depth of 28 to 38 inches (see figure 7, page 17). Potter soils have cemented caliche 8 to 11 inches below the surface (see figure 10, page 20). In Rowena clay loam the layer of accumulated lime is at a depth of about 36 inches (see figure 11, page 21). In the sandy Miles soils it is typically below a depth of 60 inches.

The sandy Tivoli and Brownfield soils are examples of soils that are strongly leached and limited in fertility.

Plants and animals

Plants, micro-organisms, earthworms, insects, and animals that live in or on the soil all contribute to soil formation. Most of the soils of this county formed under grass. The prairie-type vegetation contributed large amounts of organic matter and helped in keeping the soil porous and granular. While decaying grass leaves and stems distributed organic material on the soil surface and darkened the surface layers, a myriad of micro-organisms decomposed the roots and distributed organic material throughout the soil. Thus, most of the soils in the county are dark colored, and most have a network of tubes and pores, left by the decaying roots and earthworm activity, that provide for the passage of air and water.

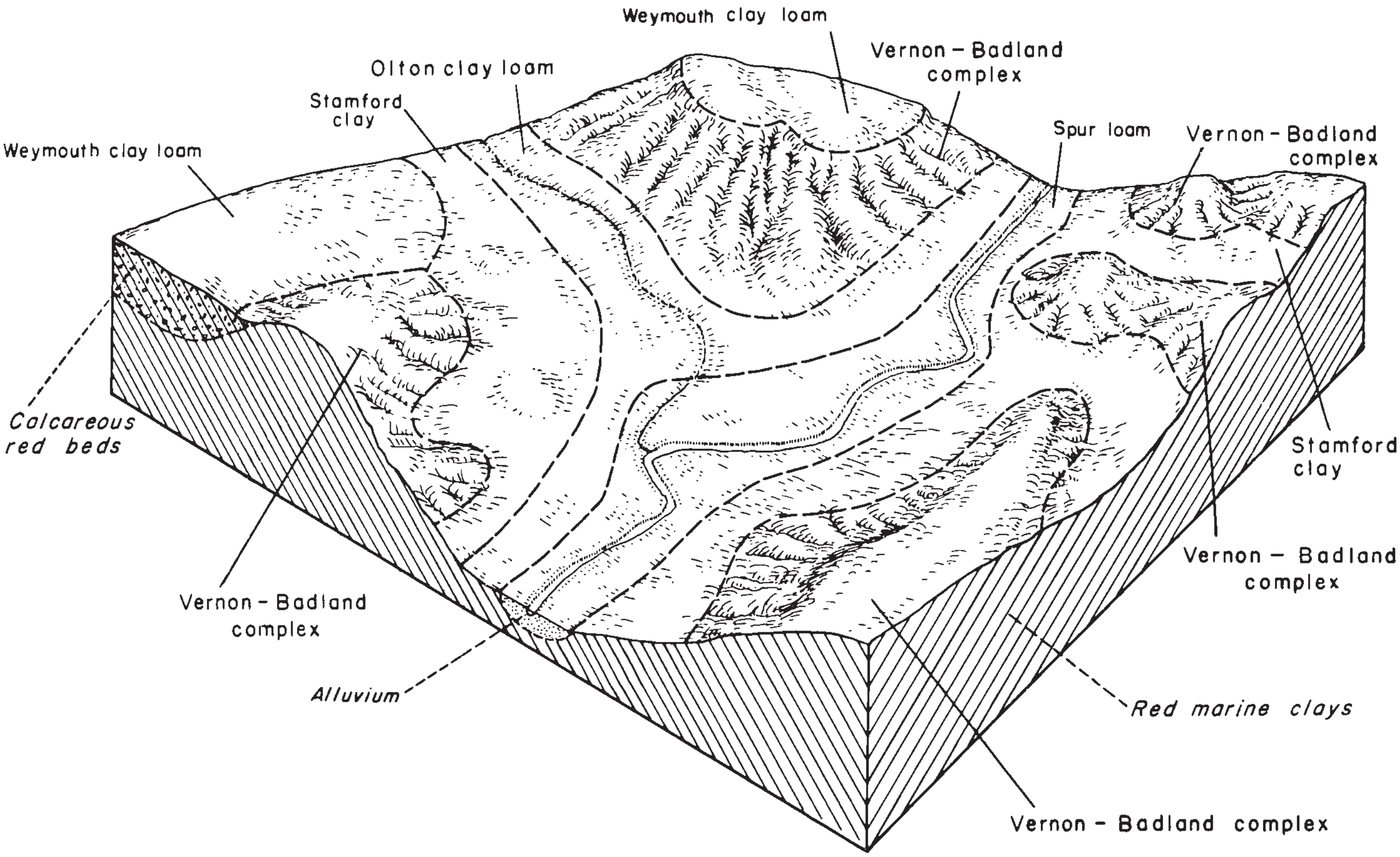

Figure 16.—Soils formed in red marine clay.

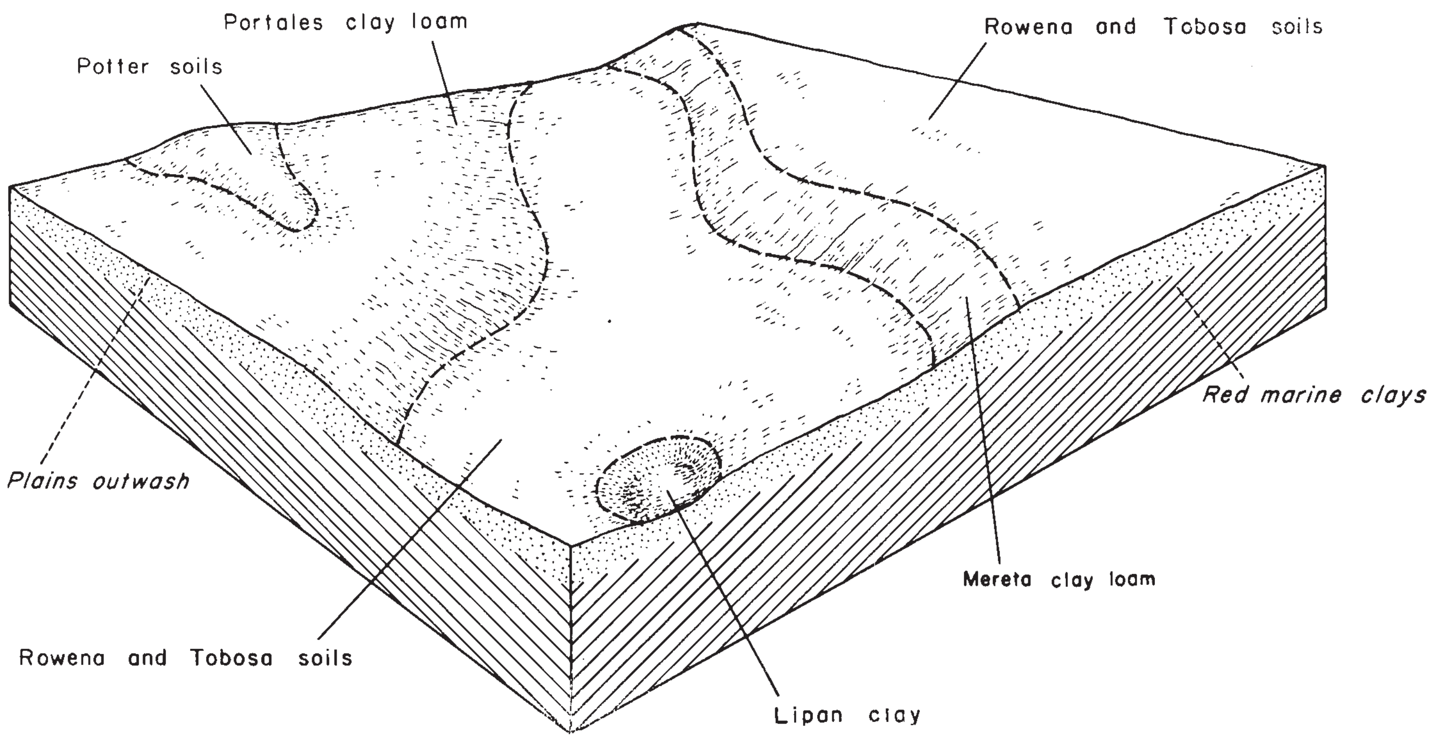

Figure 17.—Soils formed in plains outwash.

Figure 18.—**Strongly cemented, cracked caliche under Mereta clay loam.**

Some insect, worm, and animal activity tends to keep the soils supplied with minerals by bringing up unleached parent material to the surface. Burrowing animals like badgers and prairie dogs mix and loosen soil material. The burrowing of these animals extends to a depth of 15 feet, into the calcareous materials of the outwash plains. Burrowing also increases the amount of lime at the surface.

Man, too, affects soil formation in various ways. Many of man's activities drastically change soils. Plowing, for example, mixes the upper layers, hastens the decay of organic matter, lightens the color, and exposes the soil to erosion (fig. 19). Construction activities also are likely to alter soils. Some soils are excavated or buried and mixed with worthless material; some are leveled and made deeper and subsequently have slower runoff.

Relief

Relief influences soil development through its effect on drainage and runoff. It is commonly a local rather than a regional factor in soil formation.

Runnels County has both constructional topography and erosional topography. The constructional landforms have deep accumulations of soil material and smooth surface features. The erosional forms have little or no soil material and rough surfaces.

The outwash plain, which consists of all but the eastern and northwestern margins of the county, has flat or rolling topography. Since the parent material was fairly uniform, the depth and other characteristics of the soils of the outwash plain are determined to a great extent by slope, which controls runoff and the amount of water that passes through the soil material. Potter, Mereta, Portales, Rowena, Tobosa, Miles, and Lipan soils formed in this area. Of these, the deepest Portales, Rowena, Tobosa, Miles, and Lipan soils have the least relief, and the shallow Potter soils the strongest relief. Mereta soils are intermediate in depth and in relief.

The strongest relief in the county is in the northeastern part; a drop of 300 feet within a distance of a quarter of a mile is common. The hills have nearly level tops and steep side slopes. The shallow Tarrant soils formed on the hillsides, where runoff was rapid and, consequently, erosion was severe and little moisture penetrated the soil material. The somewhat deeper Kavett soils formed on the hilltops, where erosion was less severe and more moisture was absorbed.

Adjoining these steep areas are gently sloping to steep slopes composed of outwash. Where vegetation grew on these slopes, the water-intake rate was high and the deep Karnes and Winters soils formed.

East of Ballinger is a rolling but deeply dissected landscape in which erosion has been active. The soils are mostly shallow or very shallow. The slopes have a stairstep appearance, because the underlying rock consists of alternating layers of hard limestone and less hard marl. Where the hard limestone is exposed, the slopes are short and steep and the soils are of the Talpa series. Where the less resistant marl is exposed, the slopes are longer and the soils are of the Kavett series.

At scattered places in the county are rolling lowlands and eroded uplands of red marine clay and shale, like the material under the outwash plain sediments. The soils in these areas are of the Vernon, Weymouth, and Stamford series.

Time

A great length of time is required for such soil-forming factors as climate, relief, and living organisms to show their influence on soil characteristics.

Many of the soils in this county are immature, that is, the soil-forming processes are not complete. Some parent materials that have been in place for only a short time have undergone only minor changes. There are few changes in Colorado and Yahola soils, for example, other than a slightly darker colored surface layer, which has been caused by decaying organic material.

Some of the older soils are calcareous and have a noticeable accumulation of calcium carbonate. Further aging would allow leaching to the extent that the calcium carbonate would move downward from the upper horizons and accumulate in the lower horizons. Olton, Winters, Acuff, and Miles soils have been developing long enough to have formed a horizon of illuviated clay below the surface horizon.

Figure 19.—**Most of plowed layer removed during one rainstorm. The soil is Mereta clay loam, 1 to 3 percent slopes.**

In some soils time is unimportant because some of the other soil-forming factors dominate. Tarrant soils remain shallow because of the dominating influence of relief and parent materials. The steep slopes cause much runoff and natural erosion, and the hard parent material weathers very slowly. Time has had very little influence on Tivoli soils because the parent materials are mostly sands. Also, time has had little influence on depth and horizonation in the shallow Vernon soils because the parent material is clay that does not weather rapidly. In fact, this clay is nearly impervious to water.

The time factor is offset when new parent material is brought to the surface by burrowing animals and soil development must start anew.

Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories, so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and revised later (*5*). The system currently used by the National Cooperative Soil Survey was adopted in 1965. (*7*) It is under continual study. Readers interested in the development of the system should refer to the latest literature available (*4*).

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 6 shows the classification of the soil series of Runnels County by family, subgroup, and order, according to the current system.

TABLE 6.—*Classification of soil series*

Series	Family	Subgroup	Order
Acuff	Fine-loamy, mixed, thermic	Typic Paleustolls	Mollisols.
Brownfield	Loamy, mixed, thermic	Arenic Paleustalfs	Alfisols.
Cobb	Fine-loamy, mixed, thermic	Udic Haplustalfs	Alfisols.
Colorado	Fine-loamy, mixed, calcareous, thermic	Typic Ustifluvents	Entisols.
Karnes	Fine-carbonatic, thermic	Rendollic Ustochrepts	Inceptisols.
Kavett	Clayey, montmorillonitic, thermic, shallow	Petrocalcic Calciustolls	Mollisols.
Latom	Loamy, mixed, calcareous, thermic	Lithic Torriorthents	Entisols.
Lipan	Fine, montmorillonitic, thermic	Chromic Entic Pellusterts	Vertisols.
Mereta	Clayey, mixed, thermic, shallow	Petrocalcic Calciustolls	Mollisols.
Miles	Fine-loamy, mixed, thermic	Udic Paleustalfs	Alfisols.
Olton	Fine, mixed, thermic	Typic Paleustolls	Mollisols.
Portales	Fine-carbonatic, thermic	Typic Calciustolls	Mollisols.
Potter	Fine-carbonatic, thermic, shallow	Ustollic Calciorthids	Aridisols.
Rowena	Fine, mixed, thermic	Vertic Calciustolls	Mollisols.
Spur	Fine-loamy, mixed, thermic	Fluventic Haplustolls	Mollisols.
Stamford	Fine, montmorillonitic, thermic	Typic Chromusterts	Vertisols.
Talpa	Loamy, mixed, thermic	Lithic Haplustolls	Mollisols.
Tarrant	Clayey-skeletal, montmorillonitic, thermic	Lithic Haplustolls	Mollisols.
Tivoli	Siliceous, thermic	Typic Ustipsamments	Entisols.
Tobosa	Fine, montmorillonitic, thermic	Typic Chromusterts	Vertisols.
Valera	Fine, montmorillonitic, thermic	Petrocalcic Calciustolls	Mollisols.
Vernon	Fine, mixed, thermic	Typic Ustochrepts	Inceptisols.
Weymouth	Fine-loamy, mixed, thermic	Typic Ustochrepts	Inceptisols.
Winters	Fine, mixed, thermic	Udic Paleustalfs	Alfisols.
Yahola	Coarse-loamy, mixed, calcareous, thermic	Typic Ustifluvents	Entisols.

Additional Facts About the County

Runnels County was established in 1880. The population grew rapidly until about 1910 but decreased from 20,858 in 1910, to 18,903 in 1940, and to 15,016 in 1960. Ballinger, the county seat and largest town, has a population of 5,043, Winters 3,266, Miles 626, Rowena 410, Wingate 250, and Norton 150.

The economy of the county is based on petroleum, field crops, livestock, and light industry.

The 1964 census showed 1,113 farms and ranches in the county and the average size of farms as 552 acres. Of the farm operators, 451 were full owners, 335 were part owners, 325 were tenants, and 2 were managers.

Oil was discovered in 1927. There are now many small producing oilfields in the county. The total production since 1927 exceeds 100 million barrels. Dairy products and meat products are important in the economy of the county. Other industries are the manufacture of machine shop products, the manufacture of plastic signs, and commercial feed processing. There are also commercial feedlots.

Climate [4]

Runnels County has a warm-temperate, subtropical climate. Winters are dry, and summers are humid. Table 7 shows, by months, the average daily maximum temperatures, the average daily minimum temperatures, and the average precipitation for the county.

The rainfall pattern is typical of the Rolling Plains. The average annual rainfall is 22.3 inches. About two-thirds of this amount falls during the period from April through September. The heaviest rains occur as thunderstorms, and the amount varies widely from year to year. The range has been from 10.7 inches, in 1917, to 50.6 inches, in 1935.

The wide range in temperature typical of a continental climate is typical of Runnels County. Periods of cold weather are short. Fair, mild weather frequently occurs in January. Hot daytime temperatures prevail for a long period in summer but are broken by thunderstorm activity on an average of about five times a month. The temperature drops rapidly after nightfall, and the minimum average in summer is about 70° F. High temperatures in summer are usually associated with fair skies, southwesterly winds, and low humidity. Rapid changes in temperatures occur in winter as cold, dry polar air replaces warm, moist tropical air. The temperature sometimes drops as much as 20 to 30 degrees in an hour.

Sunshine is abundant. On the average, the area receives about 70 percent of the total amount possible. Seasonally, the percentage ranges from the low sixties in winter to the upper seventies in summer. Average cloud cover varies between about six-tenths in winter and four-tenths in summer.

The prevailing winds are from the south, are frequently high, and persist for several days. The strongest winds are from the north. They generally accompany the passage of cold fronts or "northers." Duststorms are infrequent. Generally they occur only with northwesterly winds.

Hailstorms or damaging windstorms may accompany any thunderstorm but generally occur late in spring or early in summer. Severe storms are infrequent. From 1959 to 1963, a total of six storms resulted in damage estimated at $10,000 or more. Only one tornado was reported during this same 5-year period.

[4] By ROBERT B. ORTON, State climatologist, U.S. Weather Bureau.

TABLE 7.—*Temperature and precipitation*

[Data from Ballinger, Runnels County, Tex., 1934–63. Elevation 1,645 feet]

Month	Temperature		Heating degree days [1]	Precipitation		
	Average daily maximum	Average daily minimum		Average total	One year in 10 will have—	
					Less than—	More than—
	°F.	*°F.*	*°F.*	*In.*	*In.*	*In.*
January	58. 0	30. 6	710	1. 26	0	3. 4
February	62. 4	34. 2	502	. 93	0	2. 3
March	70. 1	40. 2	362	1. 00	0	2. 6
April	80. 4	50. 7	123	2. 40	. 3	4. 2
May	86. 4	59. 9	18	3. 92	2. 0	5. 4
June	94. 0	68. 0	1	2. 34	. 2	6. 2
July	97. 1	70. 5	0	1. 51	0	3. 1
August	97. 7	70. 2	0	1. 66	0	4. 0
September	90. 2	63. 2	2	2. 92	. 3	5. 3
October	81. 3	52. 7	85	2. 24	0	5. 1
November	67. 3	39. 4	391	1. 13	0	2. 6
December	60. 4	32. 8	613	. 96	0	2. 0
Year	78. 8	51. 0	2, 807	22. 27	14. 2	28. 8

[1] Calculated from a base of 65° F.

The length of the freeze-free period averages 228 days but varies considerably from year to year. The average number of days between the last occurrence of a 28° reading in spring and the first in fall is 250 days. The average date of the last 32° reading in spring is March 30, and the first in fall November 13. In 1 year out of 5, a freeze is likely to occur after April 10, and in 1 year out of 5, before November 3. Because of differences in elevation and unevenness of terrain, these average dates vary locally within the county, even on the same farm.

The average annual lake evaporation is estimated at 68 inches. Of this amount, about 47 inches is evaporated during the period May through October.

Water Supply

The supply of ground water of acceptable quality and quantity is generally adequate for homes, livestock, and gardens but not for irrigation or for municipal use. There are no major underground reservoirs. Miles draws its municipal supply from the Clear Fork Reservoir. The annual withdrawal is about 90 acre-feet. An acre-foot is an acre of water 1 foot deep.

Several wells and springs that previously were sources of good-quality water have become salty. The salty water probably originates in deep underground strata. The increased withdrawal and reduced recharge and the drilling activities of the oil industry all contribute to this salting process, especially if the deeper salty water is under pressure. As good-quality water is withdrawn, it is replaced by salty water. If there are drilled passageways in the area, it is replaced more rapidly.

Surface water is fairly plentiful, but it is generally heavily silted and is in small supply in summer when it is most needed. Both Ballinger and Winters get their municipal supply from lakes. Ballinger City Lake, in Valley Creek, has a capacity of 4,000 acre-feet, and Lake Winters, on Elm Creek, a capacity of 2,700 acre-feet. The average annual flow of the Colorado River past Ballinger is about 35,760 acre-feet. In the past 54 years the maximum flow was 813,400 acre-feet, and the minimum 6,240 acre-feet. Losses through seepage and evaporation total about 68 inches annually. Thus, during low flows in summer the salts become concentrated. A strong flow of fresh water from rains is needed to dilute the salts and reduce siltation and hence benefit wildlife and enhance the recreational value of the river.

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Glossary

Alkali soil. Generally, a highly alkaline soil. Specifically, a soil that has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is reduced.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous, soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Clay. As a soil separate, mineral soil particles that are less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. (See also Texture, soil.)

Concretions. Grains, pellets, or nodules that consist of concentrations of compounds or of soil grains cemented together. They are of various sizes, shapes, and colors. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; will not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Eolian soil material. Soil parent material accumulated through wind action; commonly refers to sandy material in dunes.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, or sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused by (1) accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors than the A horizon; or (4) some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Microrelief. Minor surface configurations of the land.

Parent material. The disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability. The capacity of the soil to transmit air or water. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH value or words as follows:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Sand. As a soil separate, individual rock or mineral fragments 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz, but sand may be of any mineral composition. As a textural class, soil that is 85 percent or more sand and not more than 10 percent clay. (See also Texture, soil.)

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a textural class, soil that is 80 percent or more silt and less than 12 percent clay. (See also Texture, soil.)

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on relatively steep slopes and in swelling clays, where there is marked change in moisture content.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting upon parent material, as conditioned by relief, over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer beneath the solum, or true soil; the C or R horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by adding the words "coarse," "fine," or "very fine" to the name of the textural class.

Tilth, soil The condition of the soil, especially as to soil structure, in relation to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. An explanation of capability classification begins on page 32. The suitability of a given soil for crops and pasture and the management needed are given in the section "Descriptions of the Soils." Other information is given in tables as follows:

Acreage and extent, table 1, page 5.
Estimated yields, table 2, page 33.
Use of the soils in engineering, table 3, page 40, table 4, page 44, and table 5, page 50.

Map symbol	Mapping unit	Described on page	Capability unit	Range site	
			Symbol	Name	Page
AcA	Acuff loam, 0 to 1 percent slopes	5	IIce-5	Deep Hardland	35
AcB	Acuff loam, 1 to 3 percent slopes	6	IIe-2	Deep Hardland	35
Cl	Cobb-Latom complex	7			
	Cobb	--	IVe-4	Sandy Loam	36
	Latom	--	IVe-4	Sandstone Hills	36
CwA	Cobb-Winters fine sandy loams, 0 to 1 percent slopes	7	IIIe-4	Sandy Loam	36
CwB	Cobb-Winters fine sandy loams, 1 to 3 percent slopes	7	IIIe-4	Sandy Loam	36
CwC	Cobb-Winters fine sandy loams, 3 to 5 percent slopes	8	IVe-4	Sandy Loam	36
Cy	Colorado and Yahola soils	9	Vw-1	Loamy Bottomland	35
KaC	Karnes soils, 3 to 8 percent slopes	10	VIe-5	Sandy Loam	36
KvA	Kavett silty clay, 0 to 1 percent slopes	11	IVs-2	Shallow	36
KvB	Kavett silty clay, 1 to 3 percent slopes	11	IVe-12	Shallow	36
Lc	Lipan clay	12	IIIw-1	Deep Upland	35
McA	Mereta clay loam, 0 to 1 percent slopes	13	IIIe-6	Shallow	36
McB	Mereta clay loam, 1 to 3 percent slopes	14	IIIe-7	Shallow	36
MfA	Miles fine sandy loam, 0 to 1 percent slopes	15	IIIe-4	Sandy Loam	36
MfB	Miles fine sandy loam, 1 to 3 percent slopes	15	IIIe-4	Sandy Loam	36
MlB	Miles loamy fine sand, 0 to 3 percent slopes	15	IVe-6	Deep Sand	35
OcA	Olton clay loam, 0 to 1 percent slopes	16	IIce-4	Deep Hardland	35
OcB	Olton clay loam, 1 to 3 percent slopes	16	IIIe-2	Deep Hardland	35
PoA	Portales clay loam, 0 to 1 percent slopes	17	IIce-5	Deep Hardland	35
PoB	Portales clay loam, 1 to 3 percent slopes	18	IIe-2	Deep Hardland	35
Pt	Potter soils	19	VIIs-1	Very Shallow	37
Ro	Rough stony land	20	VIIs-3	Steep Rocky	37
RtA	Rowena and Tobosa soils, 0 to 1 percent slopes	21			
	Rowena	--	IIce-4	Deep Hardland	35
	Tobosa	--	IIce-4	Deep Upland	35
RtB	Rowena and Tobosa soils, 1 to 3 percent slopes	22			
	Rowena	--	IIIe-2	Deep Hardland	35
	Tobosa	--	IIIe-2	Deep Upland	35
Sp	Spur loam	23	IIce-1	Loamy Bottomland	35
StA	Stamford clay, 0 to 1 percent slopes	24	IIIs-2	Clay Flats	35
StB	Stamford clay, 1 to 3 percent slopes	24	IVe-8	Clay Flats	35
Tk	Talpa-Kavett complex	24			
	Talpa	--	VIIs-1	Very Shallow	37
	Kavett	--	VIIs-1	Shallow	36
TrC	Tarrant stony clay, 0 to 8 percent slopes	25	VIs-3	Low Stony Hill	36
TrD	Tarrant stony clay, 8 to 30 percent slopes	25	VIs-4	Low Stony Hill	36
Tv	Tivoli fine sand	26	VIIe-1	Deep Sand	35
Tw	Tivoli-Brownfield fine sands	26	VIIe-1	Deep Sand	35
TyA	Tobosa clay, 0 to 1 percent slopes	27	IIIs-2	Deep Upland	35
TyB	Tobosa clay, 1 to 3 percent slopes	27	IIIe-2	Deep Upland	35
VaA	Valera silty clay, 0 to 1 percent slopes	28	IIIs-2	Deep Upland	35
VaB	Valera silty clay, 1 to 3 percent slopes	28	IIIe-2	Deep Upland	35
Vb	Vernon-Badland complex	29			
	Vernon	--	VIIe-2	Shallow Redland	37
	Badland	--	VIIe-2	None	--
WeB	Weymouth clay loam, 1 to 3 percent slopes	30	IIIe-7	Shallow Redland	37
WnA	Winters fine sandy loam, 0 to 1 percent slopes	31	IIIe-4	Sandy Loam	36
WnB	Winters fine sandy loam, 1 to 3 percent slopes	31	IIIe-4	Sandy Loam	36
WnB2	Winters fine sandy loam, 1 to 3 percent slopes, eroded	31	IVe-3	Sandy Loam	36
Ya	Yahola fine sandy loam	31	IIw-1	Loamy Bottomland	35

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Or call toll-free at (866) 632-9992 (English) or (800) 877-8339 (TDD) or (866) 377-8642 (English Federal-relay) or (800) 845-6136 (Spanish Federal-relay). USDA is an equal opportunity provider and employer.

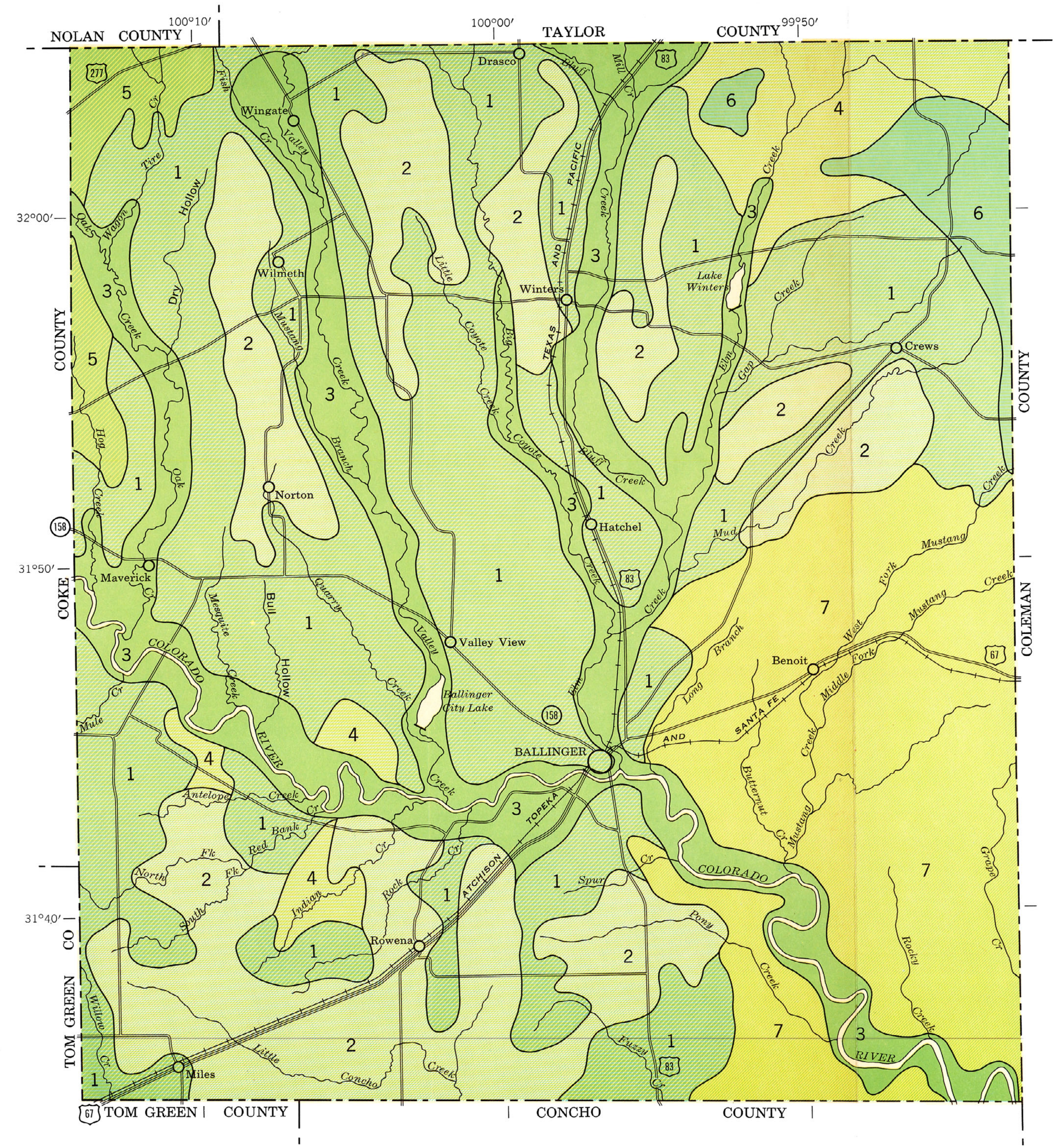
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
TEXAS AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

RUNNELS COUNTY, TEXAS

SCALE IN MILES

1 0 1 2 3 4



SOIL ASSOCIATIONS

1 — Portales–Potter–Mereta association: Nearly level to undulating, loamy soils that are moderately deep to very shallow over caliche; on outwash plains

2 — Rowena–Tobosa association: Nearly level to gently sloping, deep, loamy and clayey soils mainly on outwash plains

3 — Spur–Colorado–Miles association: Nearly level to gently sloping, deep, loamy soils mainly on flood plains but also on outwash plains and old stream terraces

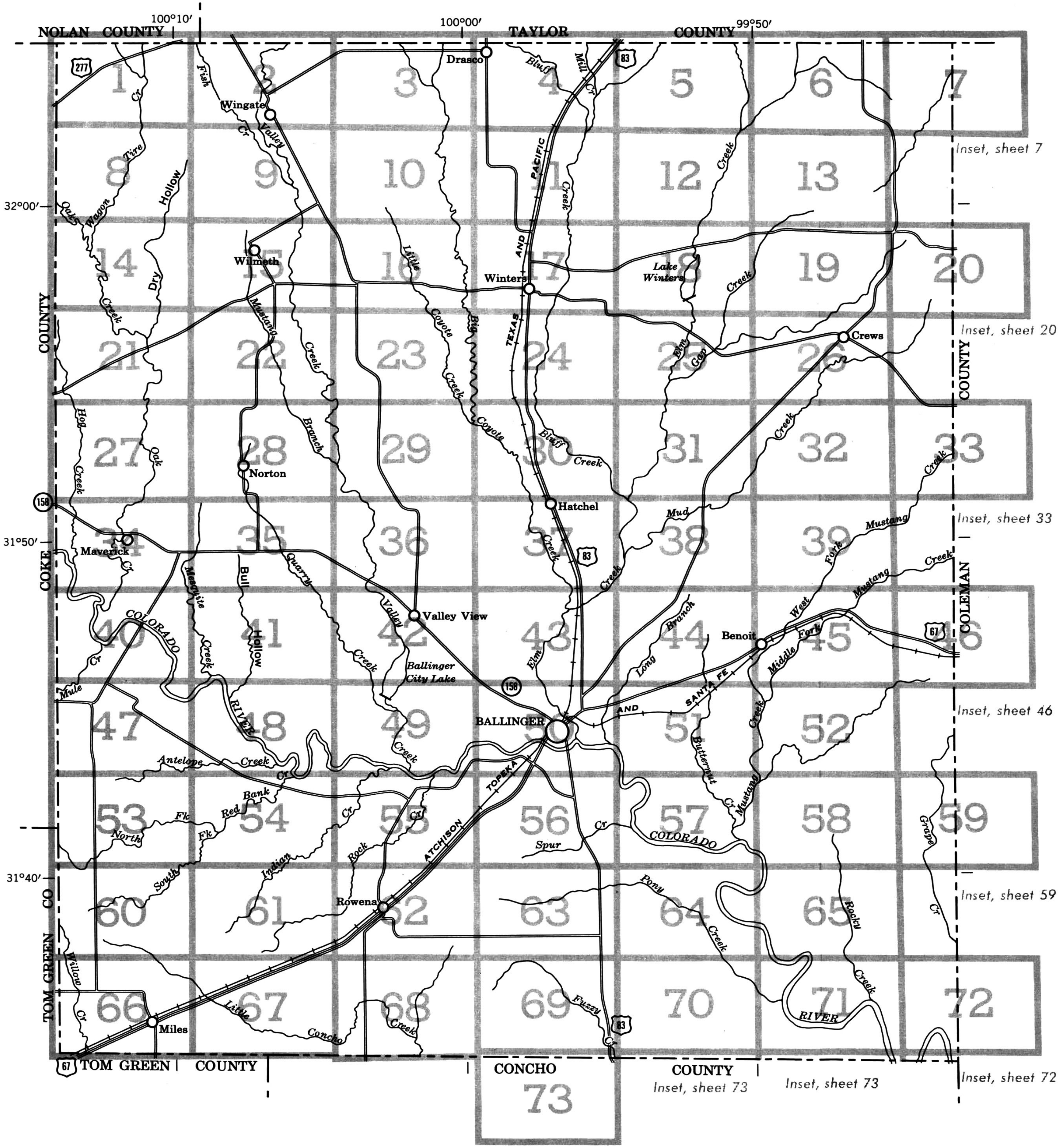
4 — Olton–Vernon–Rowena association: Nearly level to gently sloping, deep, loamy soils on outwash plains and gently sloping to steep, shallow, clayey soils on uplands

5 — Cobb–Winters association: Gently sloping to moderately sloping, moderately deep to deep, loamy soils on uplands and outwash plains

6 — Tarrant–Rough stony land association: Undulating to steep, very shallow, clayey soils and steep, stony areas

7 — Talpa–Kavett association: Undulating to steep, loamy and clayey soils that are very shallow and shallow over limestone; on uplands

December 1968



INDEX TO MAP SHEETS
RUNNELS COUNTY, TEXAS

SCALE IN MILES
1 0 1 2 3 4

Original text from each map sheet:
"This map is one of a set compiled in 1968 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Texas Agricultural Experiment Station."

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, or D, shows the slope. Most symbols without a slope letter are those of nearly level soils or land types, but some are for soils and land types that have a considerable range in slope. A final number, 2, in the symbol, shows that the soil is eroded. (W) following the soil name indicates that signs of erosion, especially of local shifting of soil by wind, are evident in places, but the degree of erosion cannot be estimated reliably.

SYMBOL	NAME
AcA	Acuff loam, 0 to 1 percent slopes
AcB	Acuff loam, 1 to 3 percent slopes
Cl	Cobb–Latom complex
CwA	Cobb–Winters fine sandy loams, 0 to 1 percent slopes
CwB	Cobb–Winters fine sandy loams, 1 to 3 percent slopes
CwC	Cobb–Winters fine sandy loams, 3 to 5 percent slopes
Cy	Colorado and Yahola soils
KaC	Karnes soils, 3 to 8 percent slopes
KvA	Kavett silty clay, 0 to 1 percent slopes
KvB	Kavett silty clay, 1 to 3 percent slopes
Lc	Lipan clay
McA	Mereta clay loam, 0 to 1 percent slopes
McB	Mereta clay loam, 1 to 3 percent slopes
MfA	Miles fine sandy loam, 0 to 1 percent slopes
MfB	Miles fine sandy loam, 1 to 3 percent slopes
MlB	Miles loamy fine sand, 0 to 3 percent slopes (W)
OcA	Olton clay loam, 0 to 1 percent slopes
OcB	Olton clay loam, 1 to 3 percent slopes
PoA	Portales clay loam, 0 to 1 percent slopes
PoB	Portales clay loam, 1 to 3 percent slopes
Pt	Potter soils
Ro	Rough stony land
RtA	Rowena and Tobosa soils, 0 to 1 percent slopes
RtB	Rowena and Tobosa soils, 1 to 3 percent slopes
Sp	Spur loam
StA	Stamford clay, 0 to 1 percent slopes
StB	Stamford clay, 1 to 3 percent slopes
Tk	Talpa–Kavett complex
TrC	Tarrant stony clay, 0 to 8 percent slopes
TrD	Tarrant stony clay, 8 to 30 percent slopes
Tv	Tivoli fine sand (W)
Tw	Tivoli–Brownfield fine sands (W)
TyA	Tobosa clay, 0 to 1 percent slopes
TyB	Tobosa clay, 1 to 3 percent slopes
VaA	Valera silty clay, 0 to 1 percent slopes
VaB	Valera silty clay, 1 to 3 percent slopes
Vb	Vernon–Badland complex
WeB	Weymouth clay loam, 1 to 3 percent slopes
WnA	Winters fine sandy loam, 0 to 1 percent slopes
WnB	Winters fine sandy loam, 1 to 3 percent slopes
WnB2	Winters fine sandy loam, 1 to 3 percent slopes, eroded
Ya	Yahola fine sandy loam

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail
- Railroad
- Ferry — FY
- Ford — FORD
- Grade
- R. R. over
- R. R. under

Tunnel

Buildings
- School
- Church

Mine and quarry

Caliche pit

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Cotton gin

BOUNDARIES

- National or state
- County
- Reservation
- Land grant
- Small park, cemetery, airport

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
  - Unclassified

Canals and ditches — CANAL

Lakes and ponds
- Perennial — water, w
- Intermittent

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

SOIL SURVEY DATA

- Soil boundary and symbol — Dx
- Gravel
- Stoniness: Stony; Very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully

Soil map constructed 1968 by Cartographic Division, Soil Conservation Service, USDA, from 1964 aerial photographs. Controlled mosaic based on Texas plane coordinate system, central zone, Lambert conformal conic projection, 1927 North American datum.

(Joins sheet 2)

(Joins sheet 8)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

2

N

(Joins sheet 1)

(Joins sheet 3)

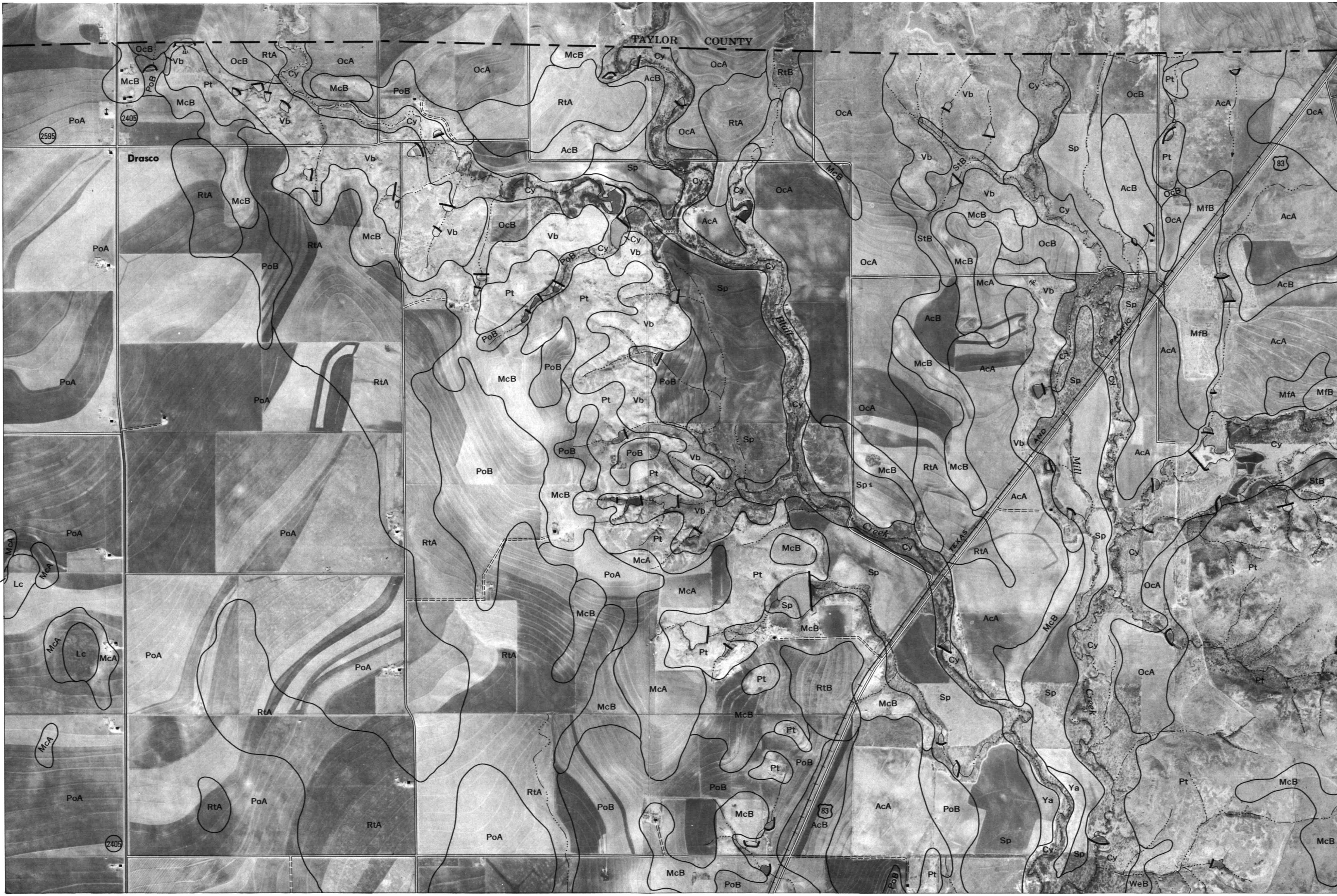
(Joins sheet 9)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

TAYLOR COUNTY
N
(Joins sheet 2)
(Joins sheet 4)
(Joins sheet 10)
Big Coyote Creek
Pumphrey
2595
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 4

N



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(Joins sheet 5)

(Joins sheet 11)

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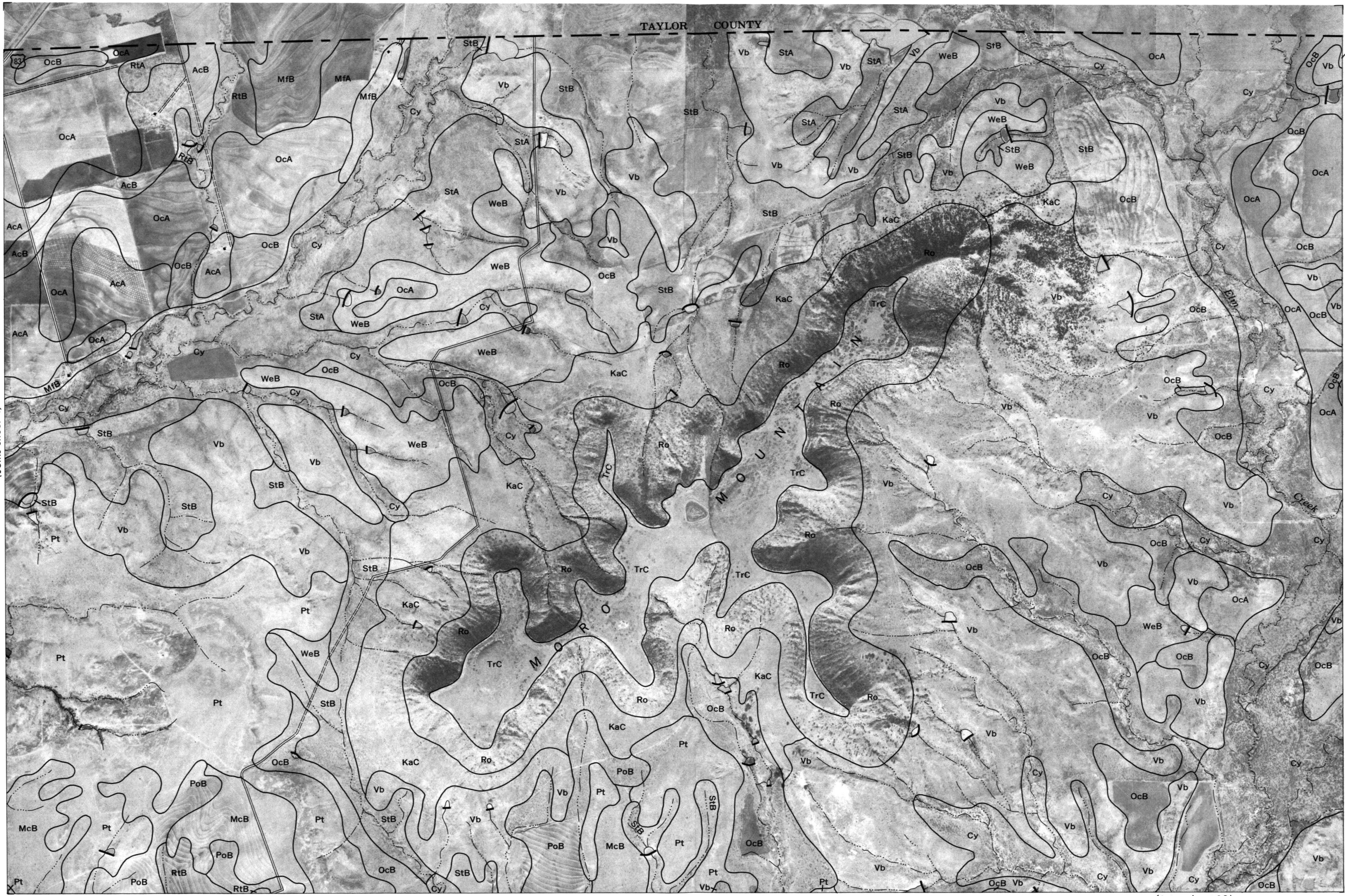

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RUNNELS COUNTY, TEXAS — SHEET NUMBER 6

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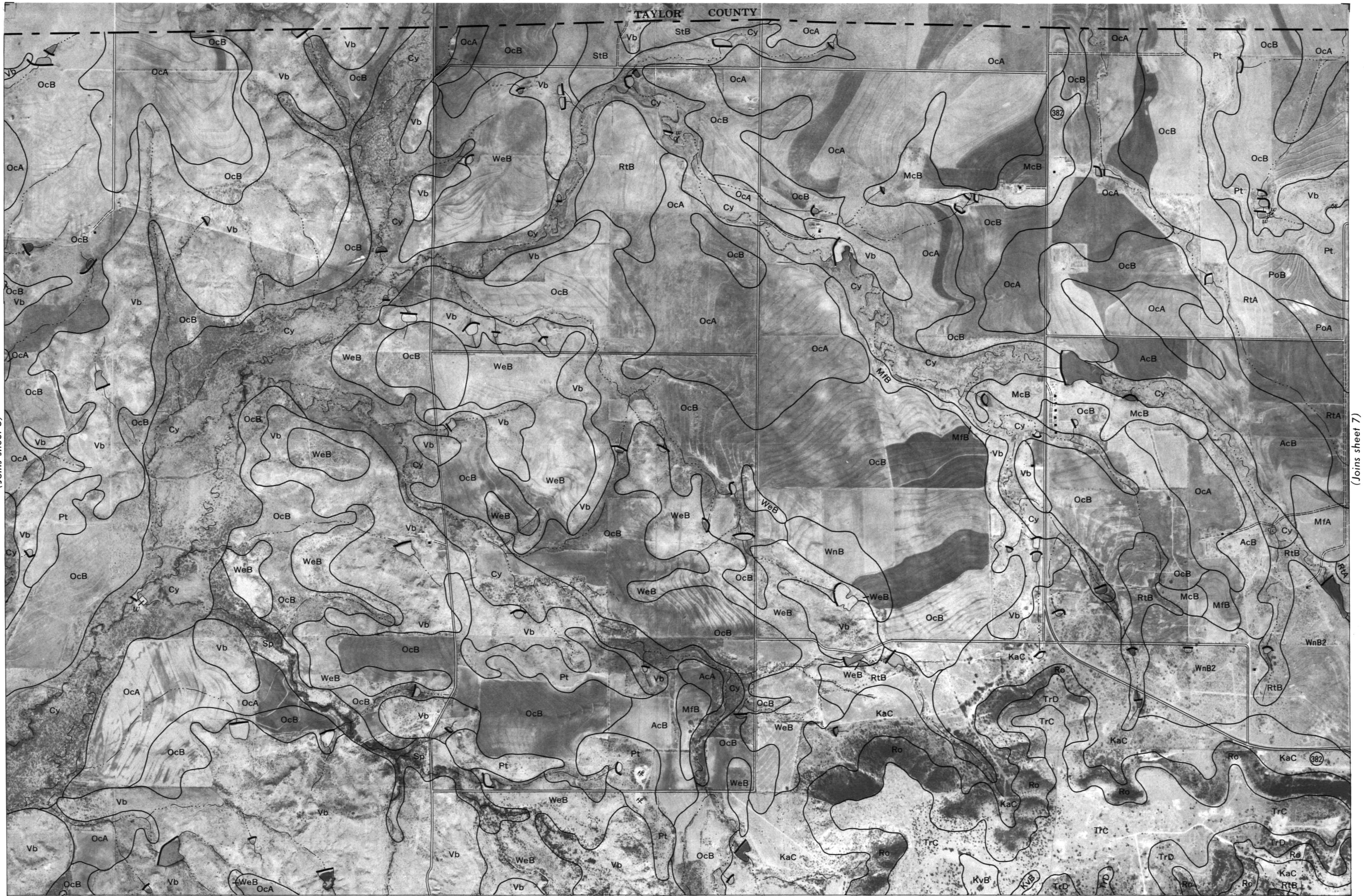
(Joins sheet 5)



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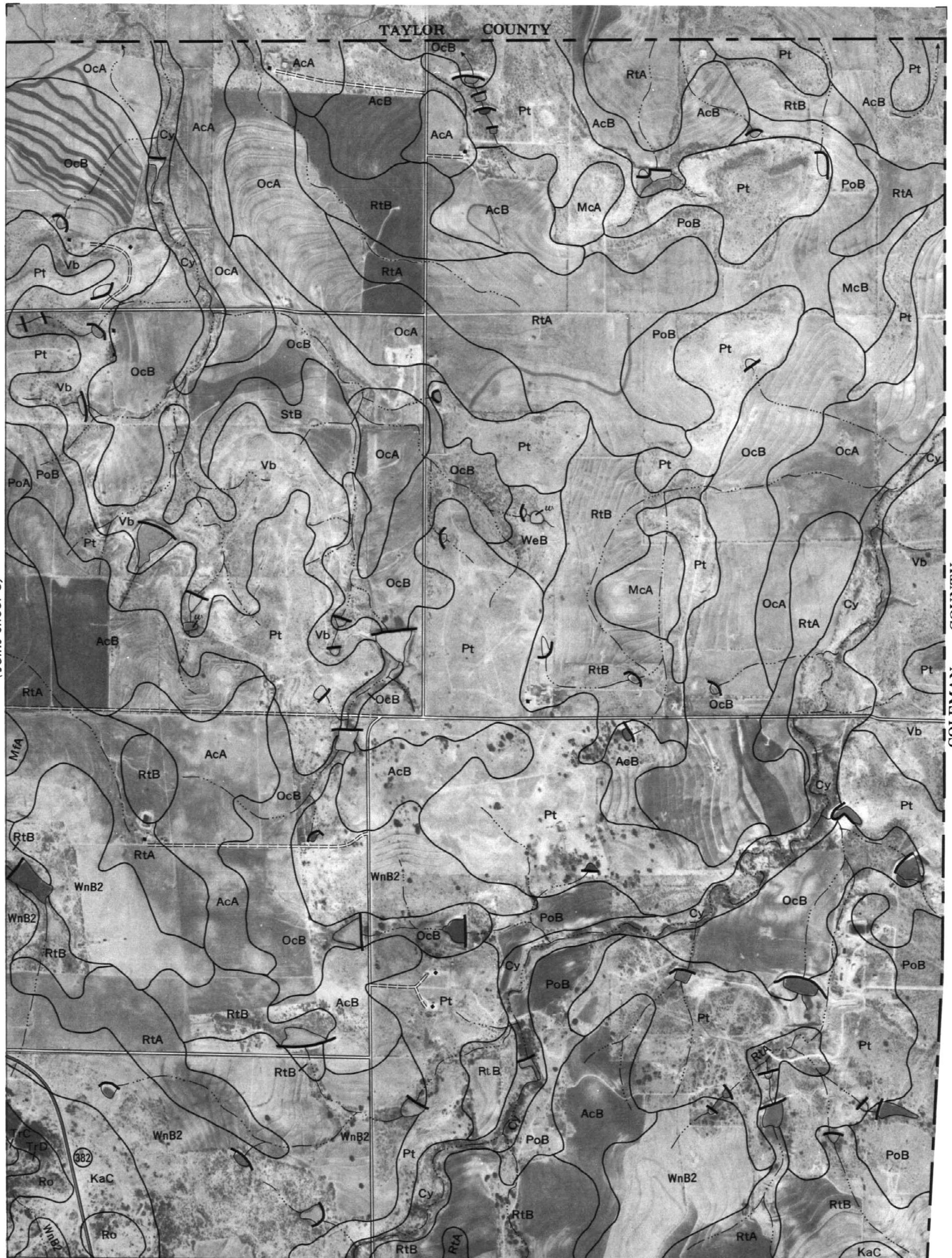

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(Joins sheet 13)

(Joins sheet 20)

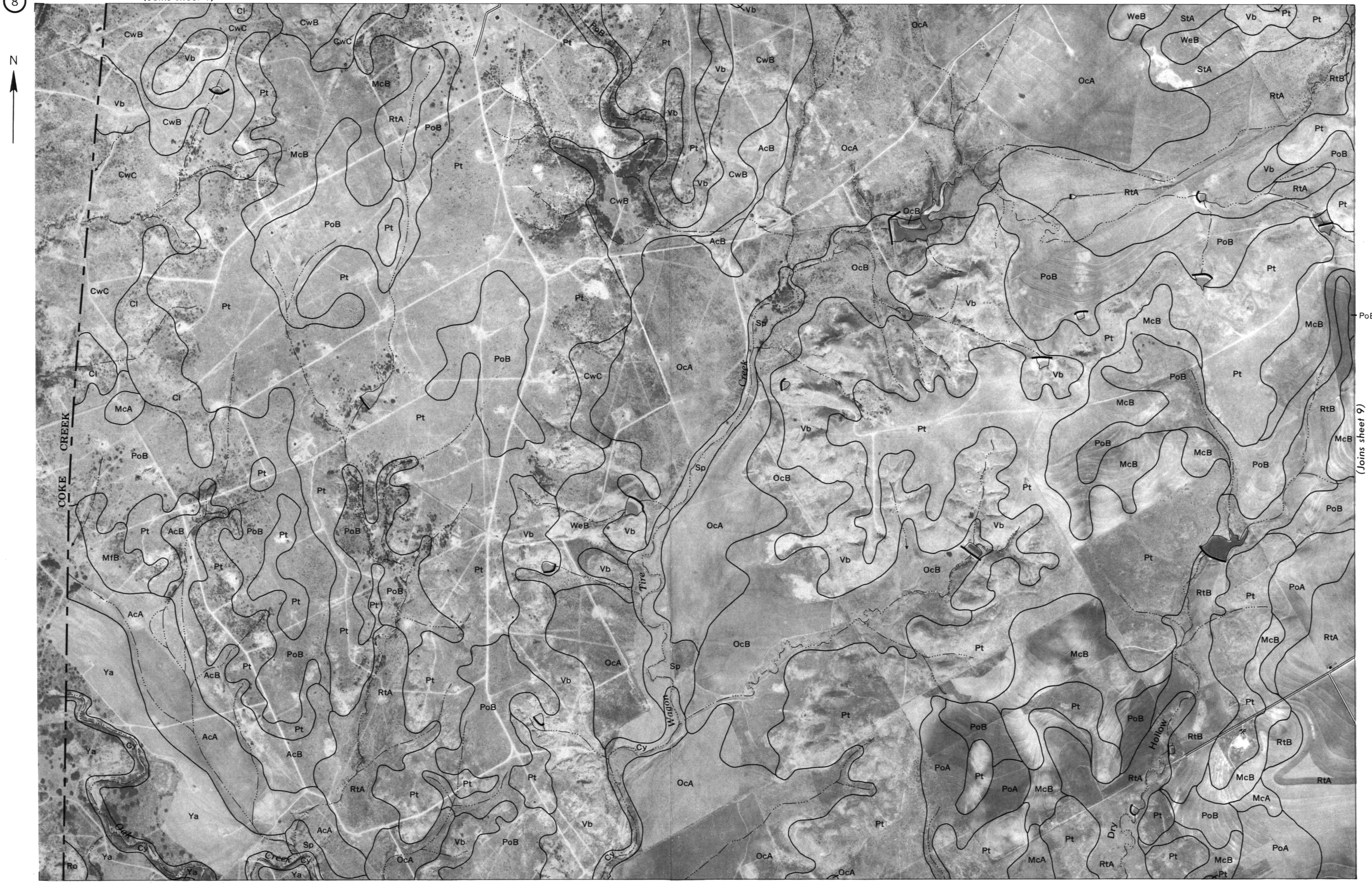
0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet

8

(Joins sheet 1)



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9

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 10

(Joins sheet 3)

N

(Joins sheet 9)

(Joins sheet 11)

(Joins sheet 16)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

12

0 ½ 1 Mile

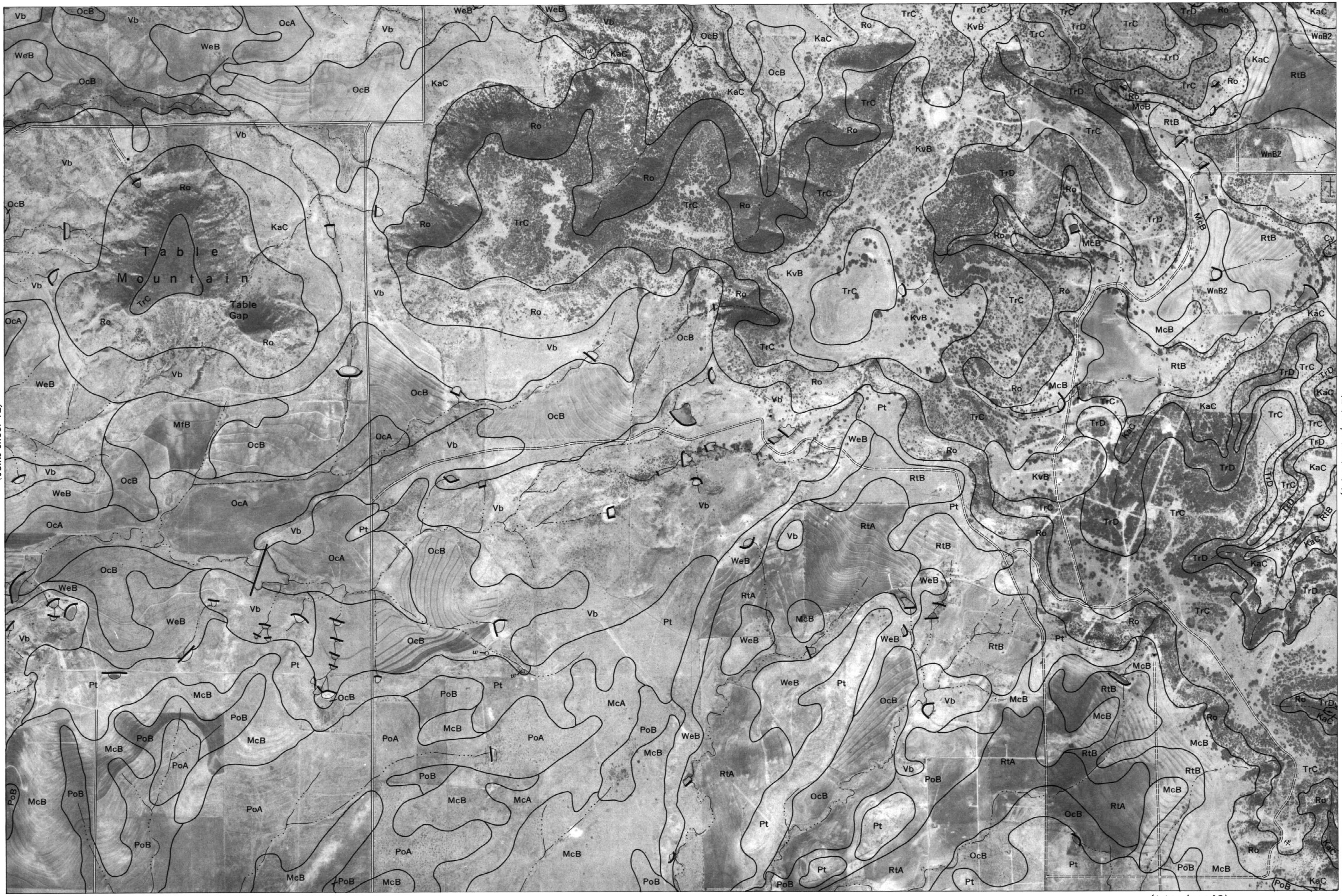
Scale 1: 20 000

0 5000 Feet

RUNNELS COUNTY, TEXAS NO. 13

(Joins sheet 6)

(Joins sheet 12)



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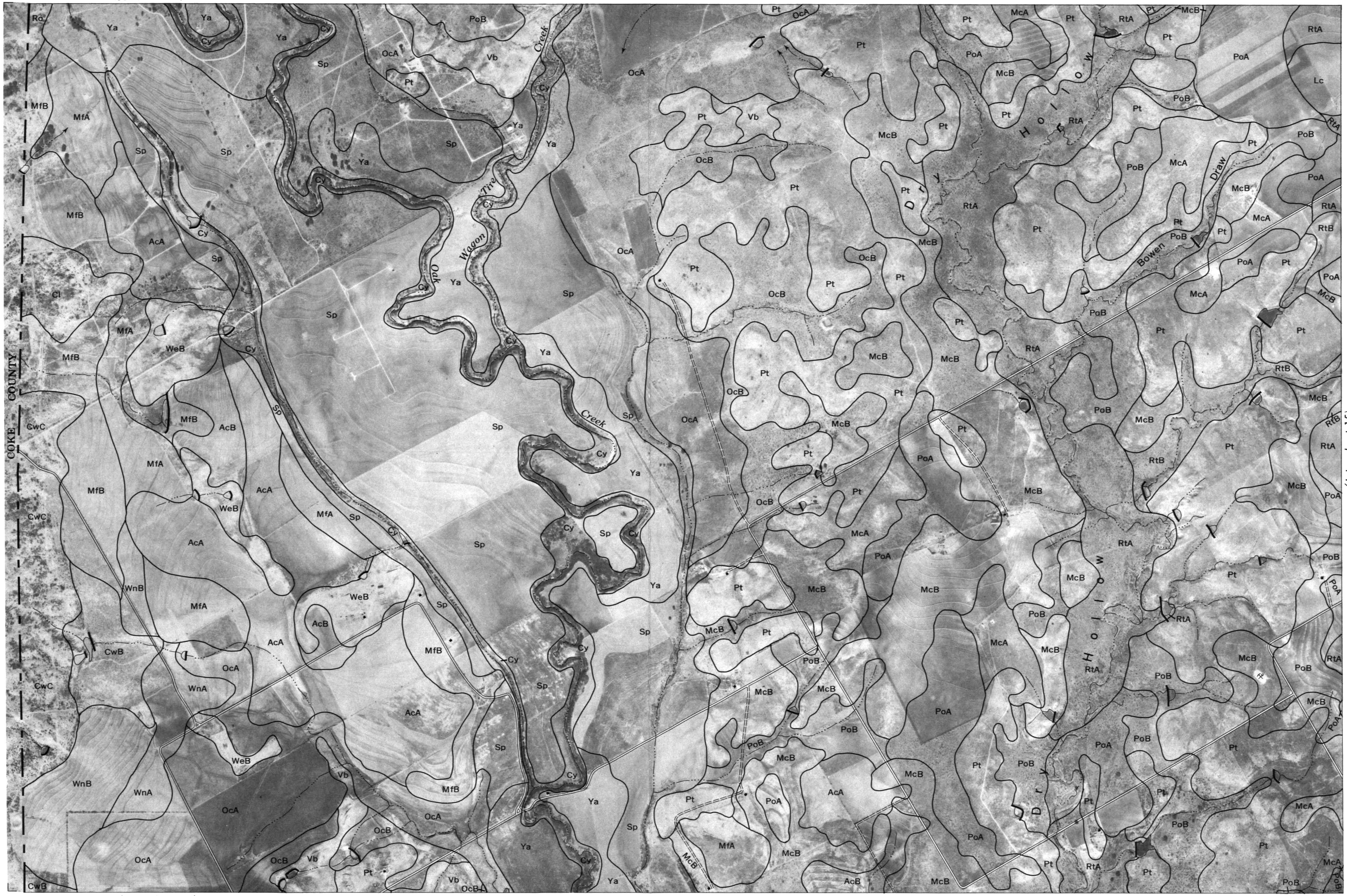

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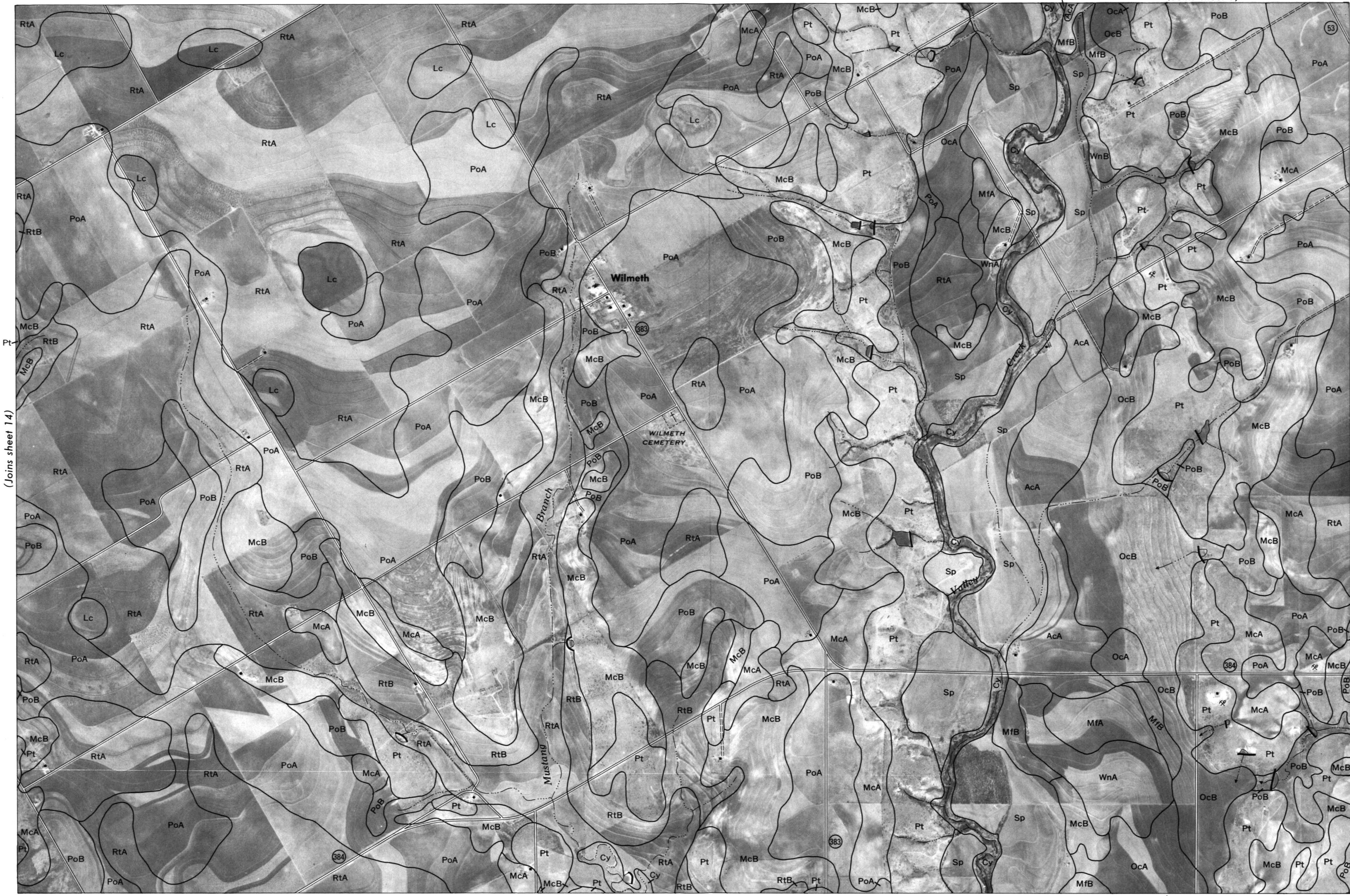

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(Joins sheet 16)

(Joins sheet 22)

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RUNNELS COUNTY, TEXAS — SHEET NUMBER 16

(Joins sheet 10)

N

(Joins sheet 15)

(Joins sheet 17)

(Joins sheet 23)

0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet

RUNNELS COUNTY, TEXAS NO. 17

(Joins sheet 11)

(Joins sheet 16)

(Joins sheet 18)

(Joins sheet 24)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 18

(Joins sheet 12)

N

(Joins sheet 17)

(Joins sheet 19)

(Joins sheet 25)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

20

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS NO. 20

(Joins sheet 14)

(Joins sheet 27)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 15)

(Joins sheet 21)

(Joins sheet 23)

(Joins sheet 28)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

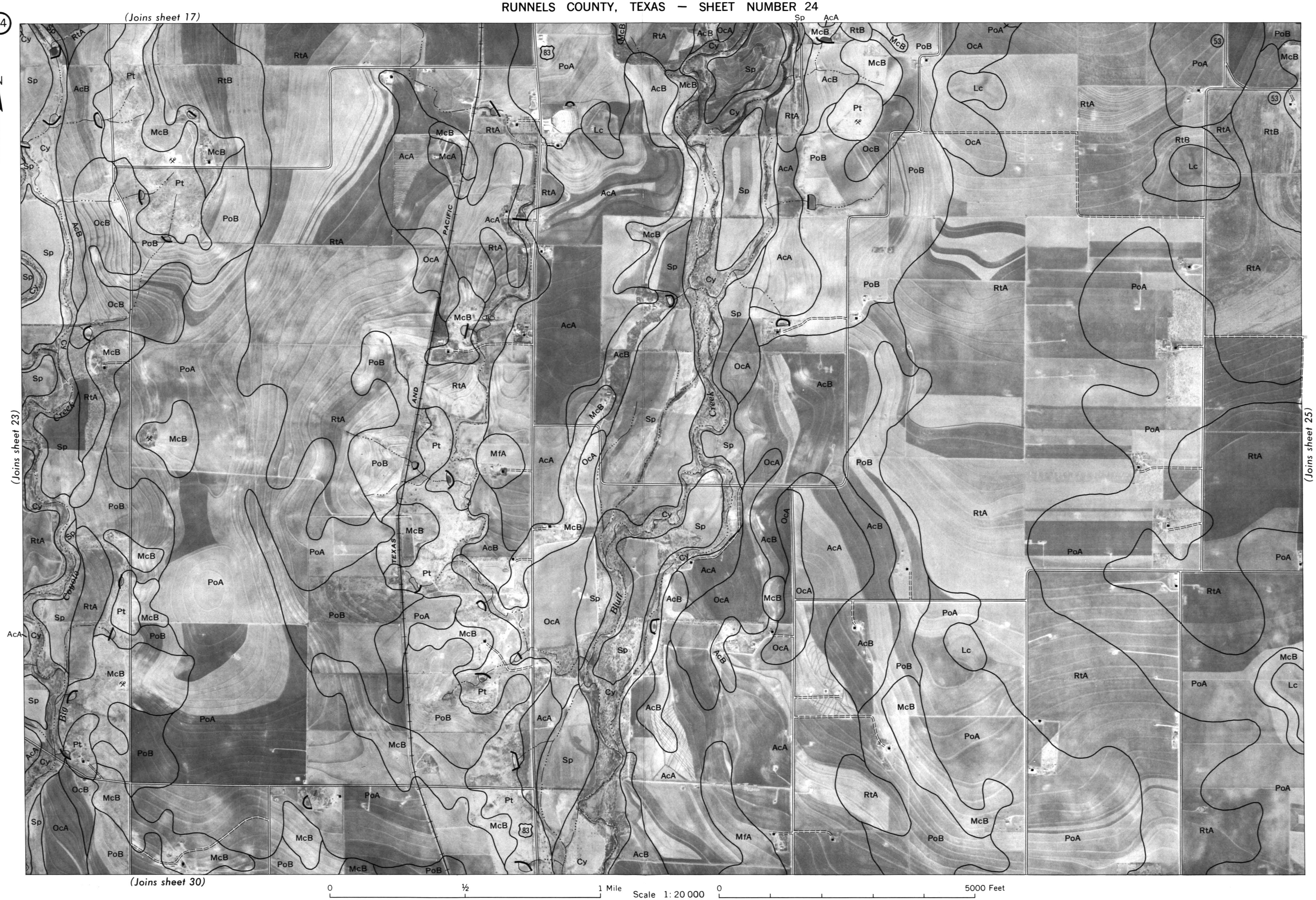
(Joins sheet 16)

(Joins sheet 22)

(Joins sheet 24)

(Joins sheet 29)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet


(Joins sheet 17)
(Joins sheet 23)
(Joins sheet 25)
(Joins sheet 30)
N
Big Coyote Creek
Bluff Creek
TEXAS AND PACIFIC
83
53
RtA
RtB
AcB
AcA
McB
McA
Pt
PoB
PoA
OcB
OcA
Sp
Cy
Lc
MfA
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

25

(Joins sheet 18)

(Joins sheet 24)

(Joins sheet 26)

(Joins sheet 31)

0 ½ 1 Mile

Scale 1 20 000

0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 26

(Joins sheet 19)

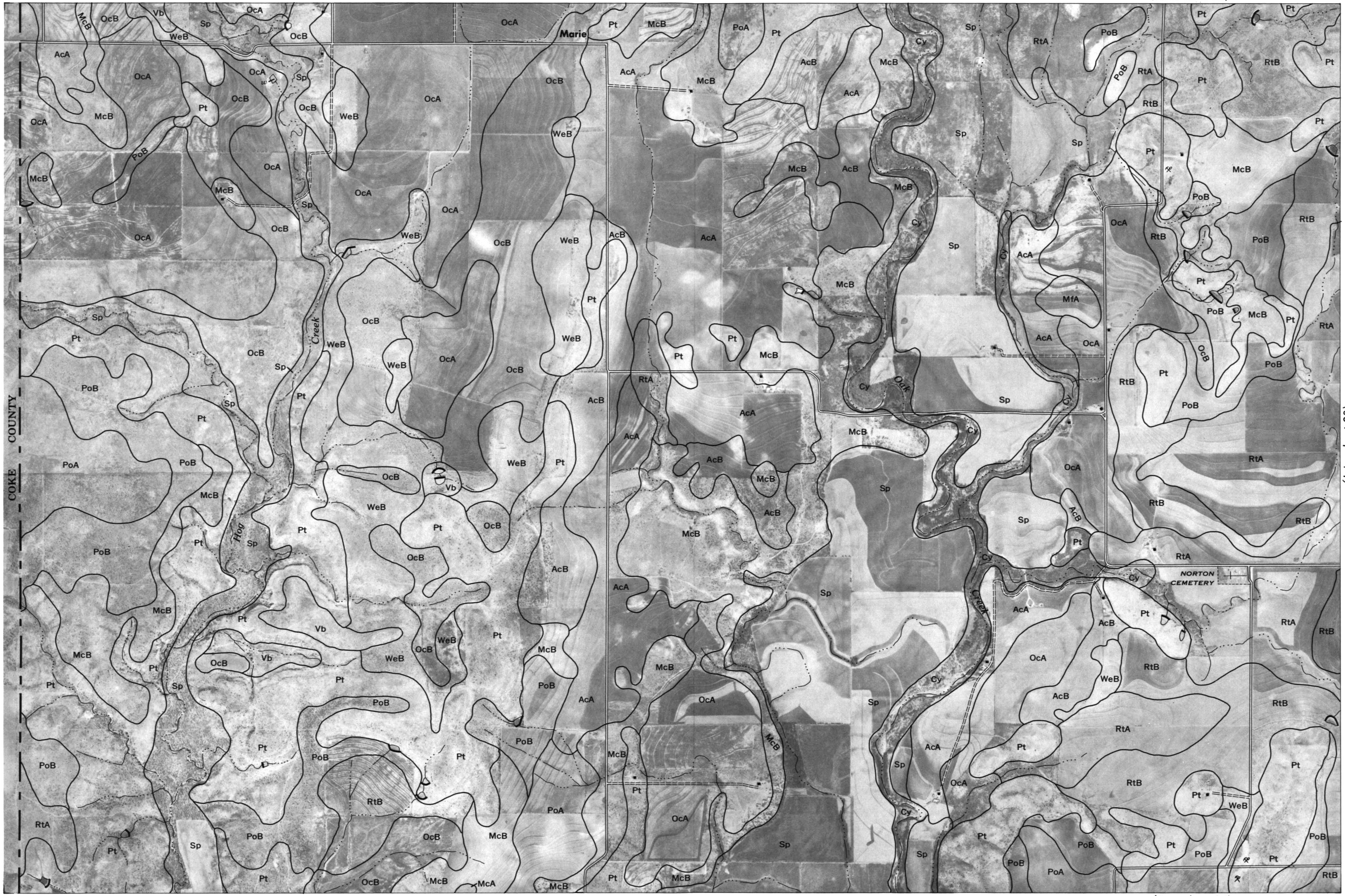
(Joins sheet 25)

(Joins inset, sheet 20)

(Joins sheet 32)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 21)



(Joins sheet 28)

(Joins sheet 34)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

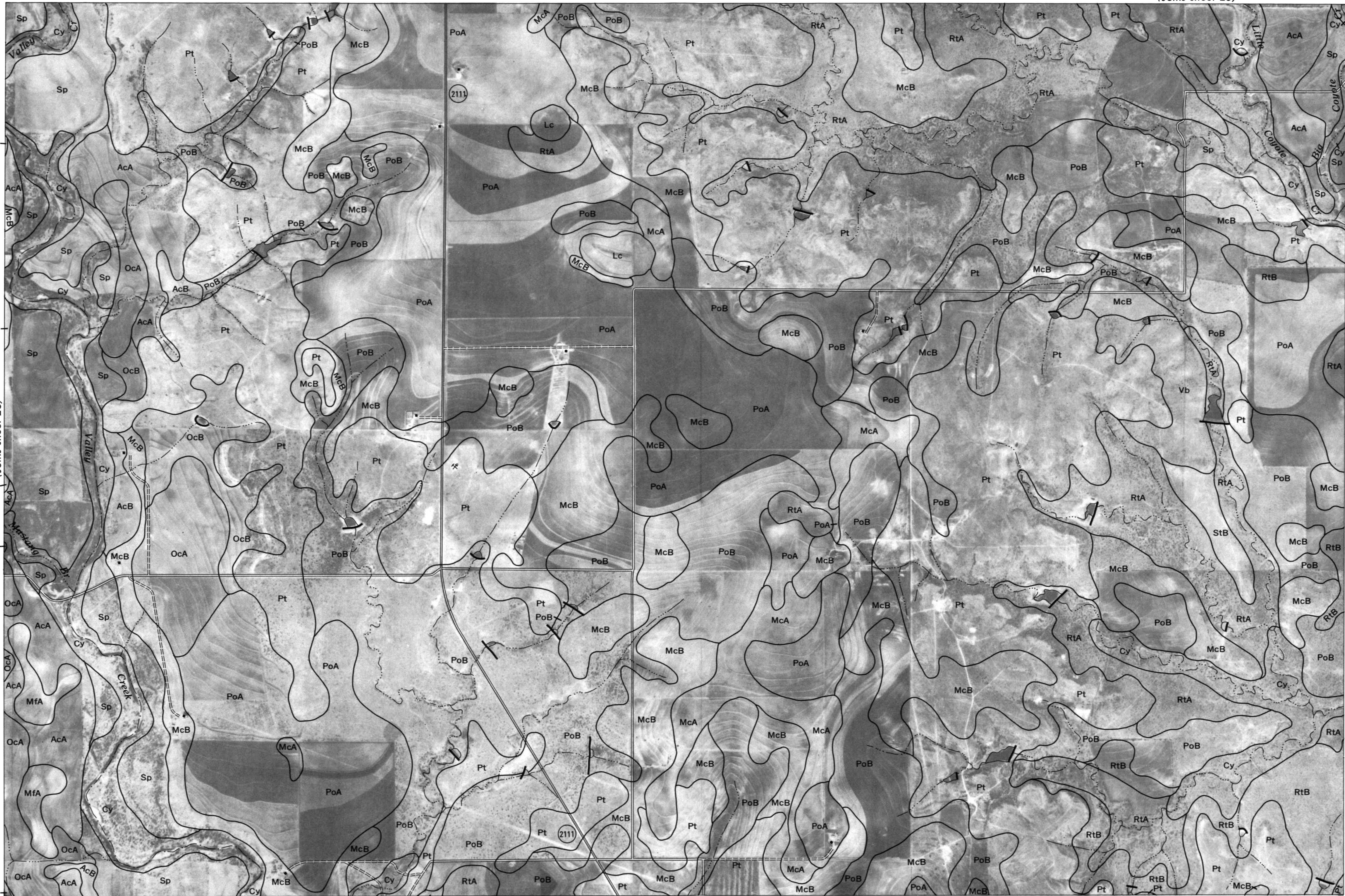
(Joins sheet 23)

29

N

(Joins sheet 28)

McB
MfB
McB
MfB
RtB



(Joins sheet 30)

(Joins sheet 36)

AcA

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 30

(Joins sheet 24)

(Joins sheet 29)

(Joins sheet 31)

(Joins sheet 37)

0 ½ 1 Mile

Scale 1:20 000

0 5000 Feet

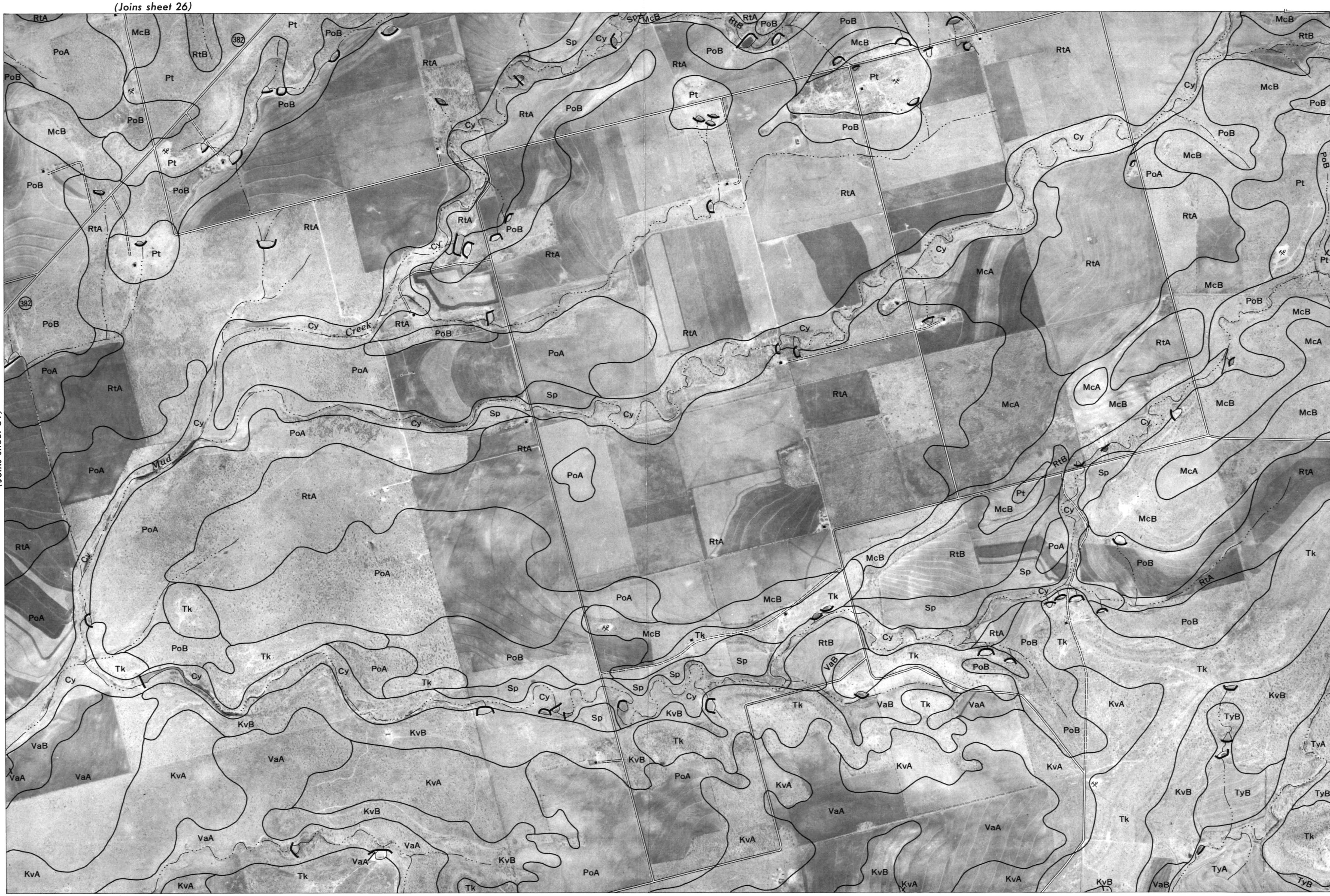
RUNNELS COUNTY, TEXAS NO. 30

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

32

(Joins sheet 26)

(Joins sheet 31)



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0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

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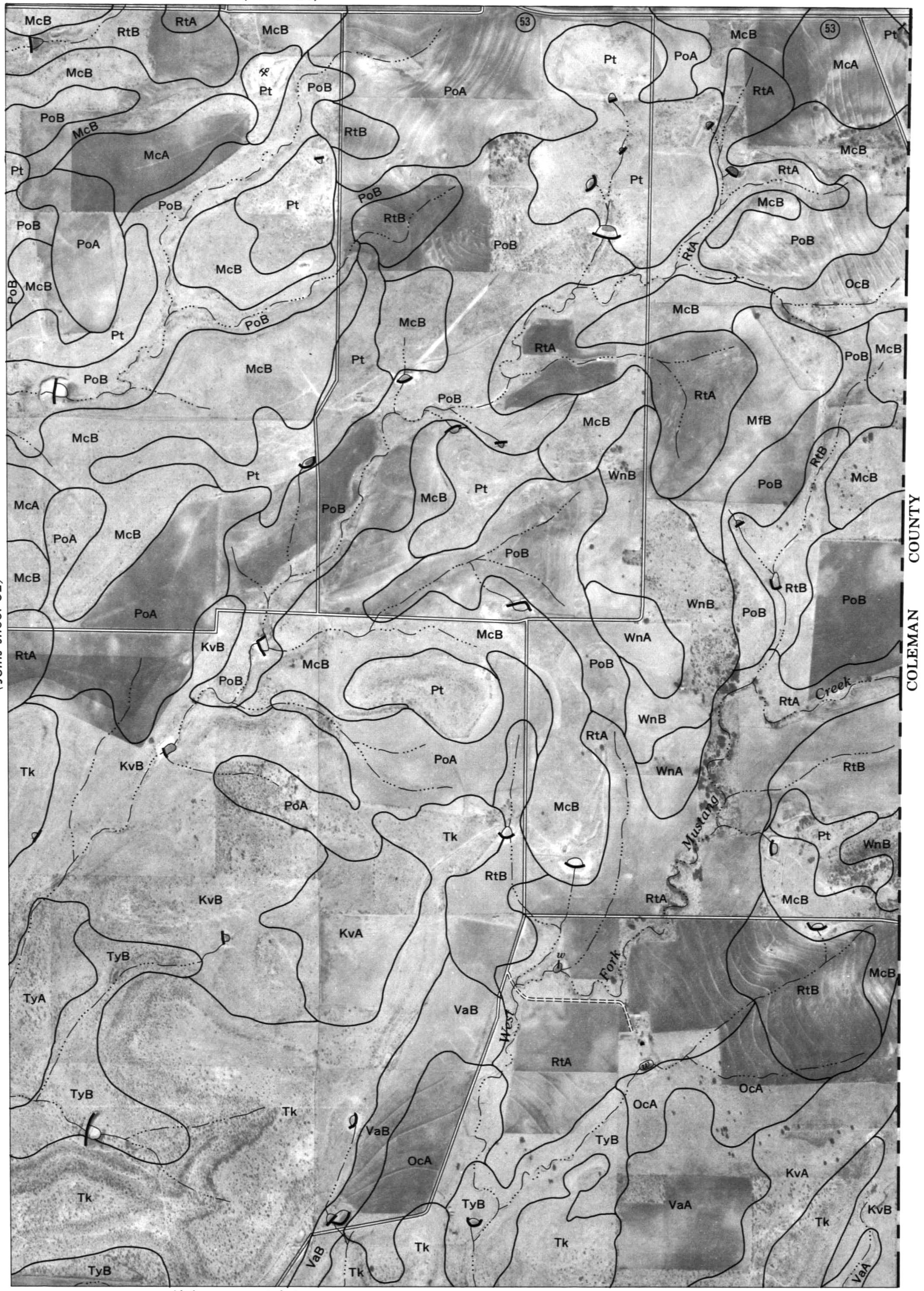
(Joins sheet 32)



COLEMAN COUNTY

(Joins upper right)

0 ½ 1 Mile

Scale 1: 20 000

(Joins lower left)

(Joins sheet 39)

COLEMAN COUNTY

N

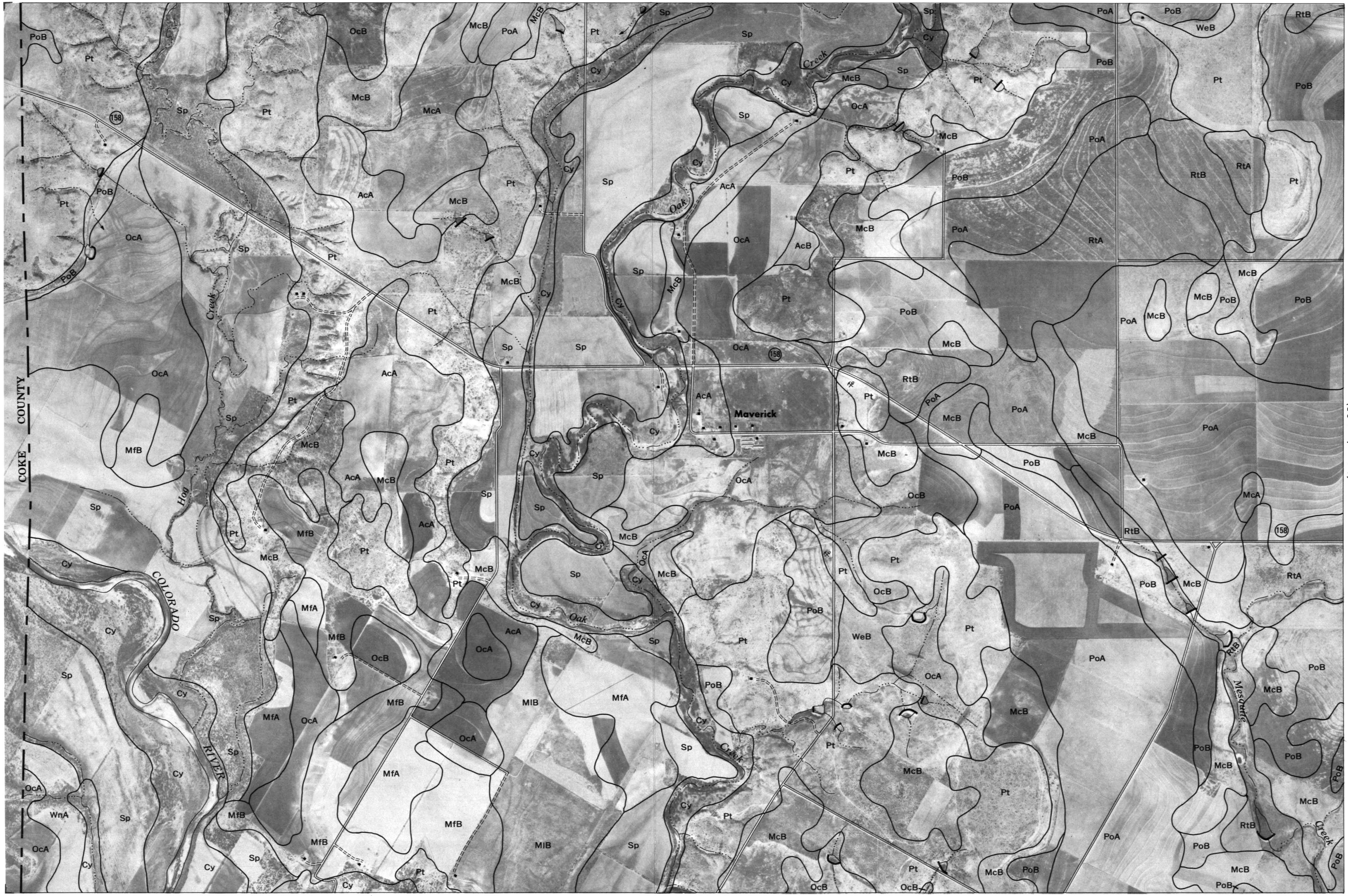
0 5000 Feet

(Joins sheet 46)

RUNNELS COUNTY, TEXAS — SHEET NUMBER 34

(Joins sheet 27)

N



(Joins sheet 35)

(Joins sheet 40)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 28)

(Joins sheet 34)

(Joins sheet 36)

(Joins sheet 41)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 29)

N

(Joins sheet 35)

(Joins sheet 37)

(Joins sheet 42)

0 ½ 1 Mile

Scale 1: 20 000

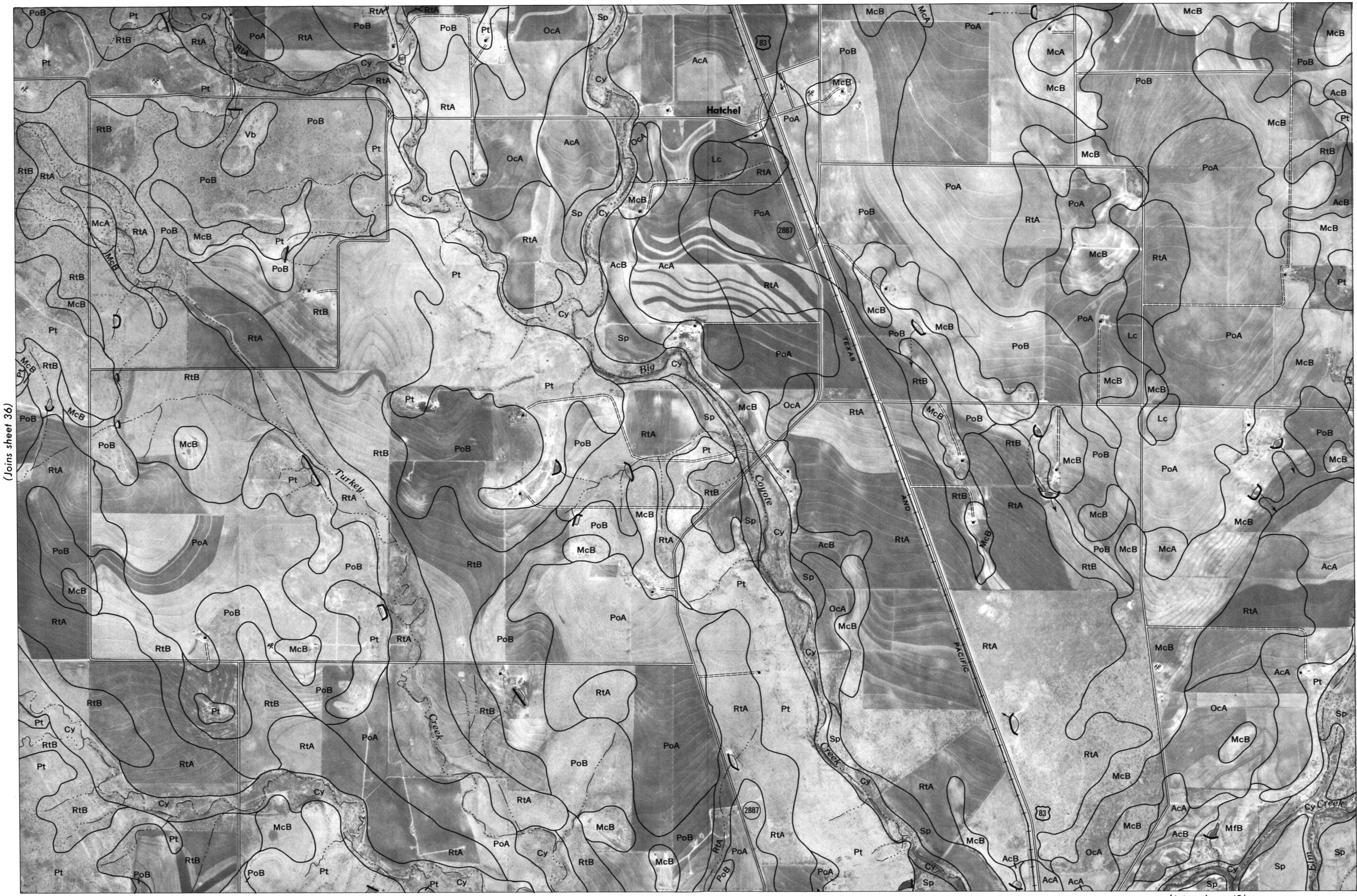
0 5000 Feet

(Joins sheet 30)

37

RUNNELS COUNTY, TEXAS NO. 37

(Joins sheet 36)



(Joins sheet 38)

(Joins sheet 43)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 31)

(Joins sheet 37)

(Joins sheet 39)

(Joins sheet 44)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

(Joins sheet 32)

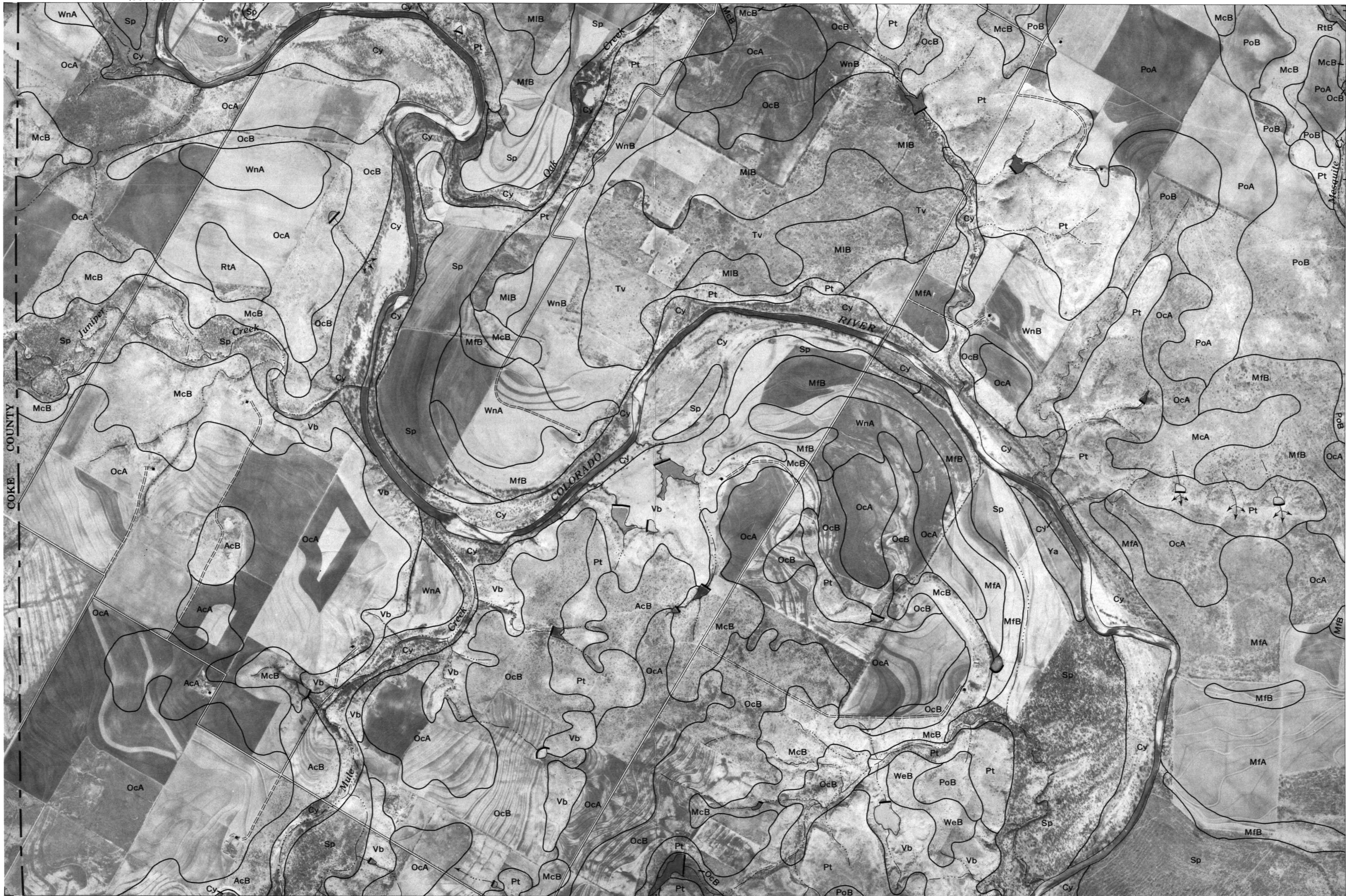
(Joins sheet 38)

(Joins inset, sheet 33)

(Joins sheet 45)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 34)



(Joins sheet 41)

(Joins sheet 47)

0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet

(Joins sheet 35)

41

(Joins sheet 40)

(Joins sheet 42)

(Joins sheet 48)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

42

N

(Joins sheet 36)

(Joins sheet 41)

(Joins sheet 43)

(Joins sheet 49)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 37)

N

(Joins sheet 42)

(Joins sheet 44)

(Joins sheet 50)

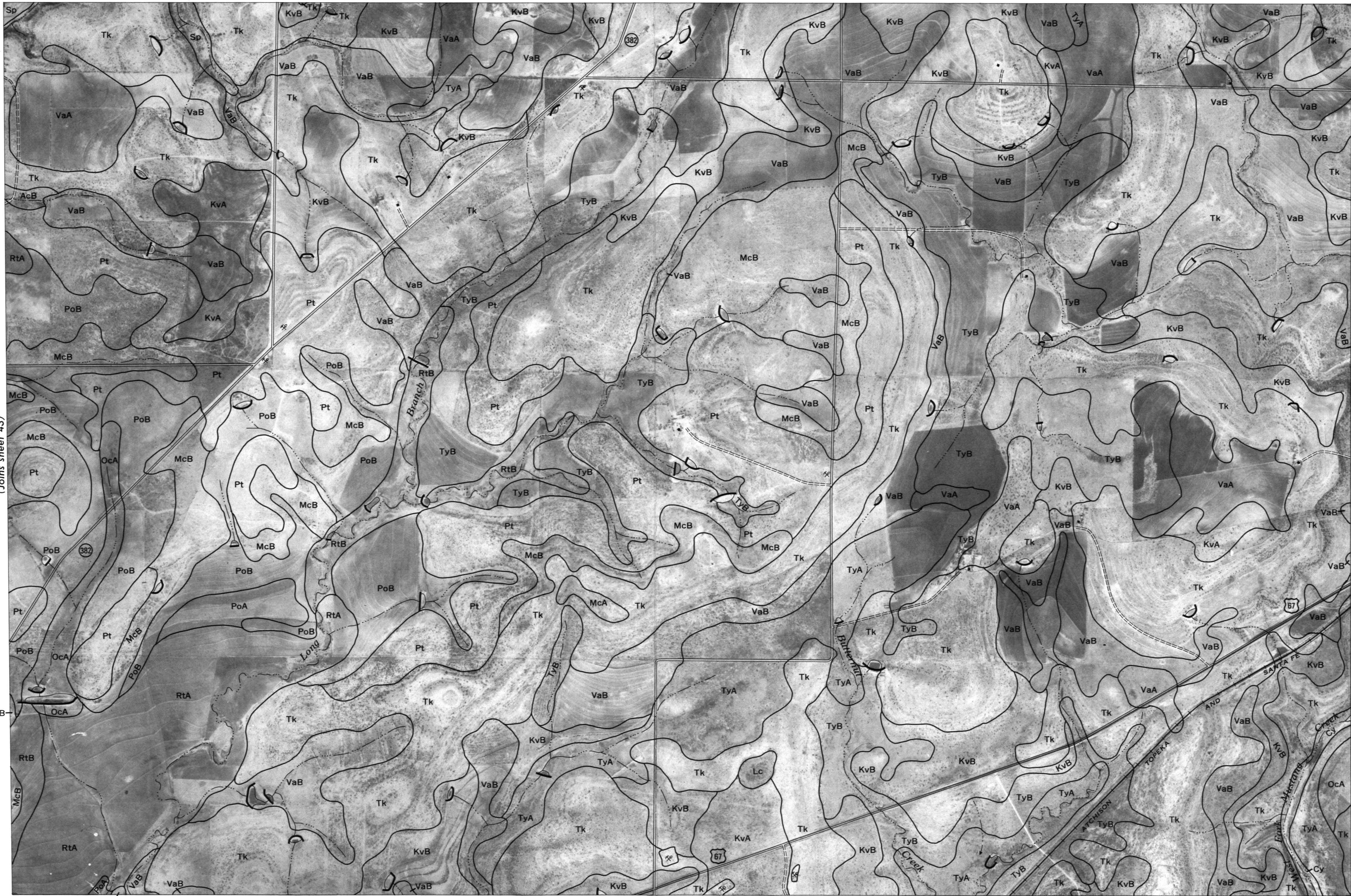
0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 44

(Joins sheet 38)

N

(Joins sheet 43)



(Joins sheet 45)

McB

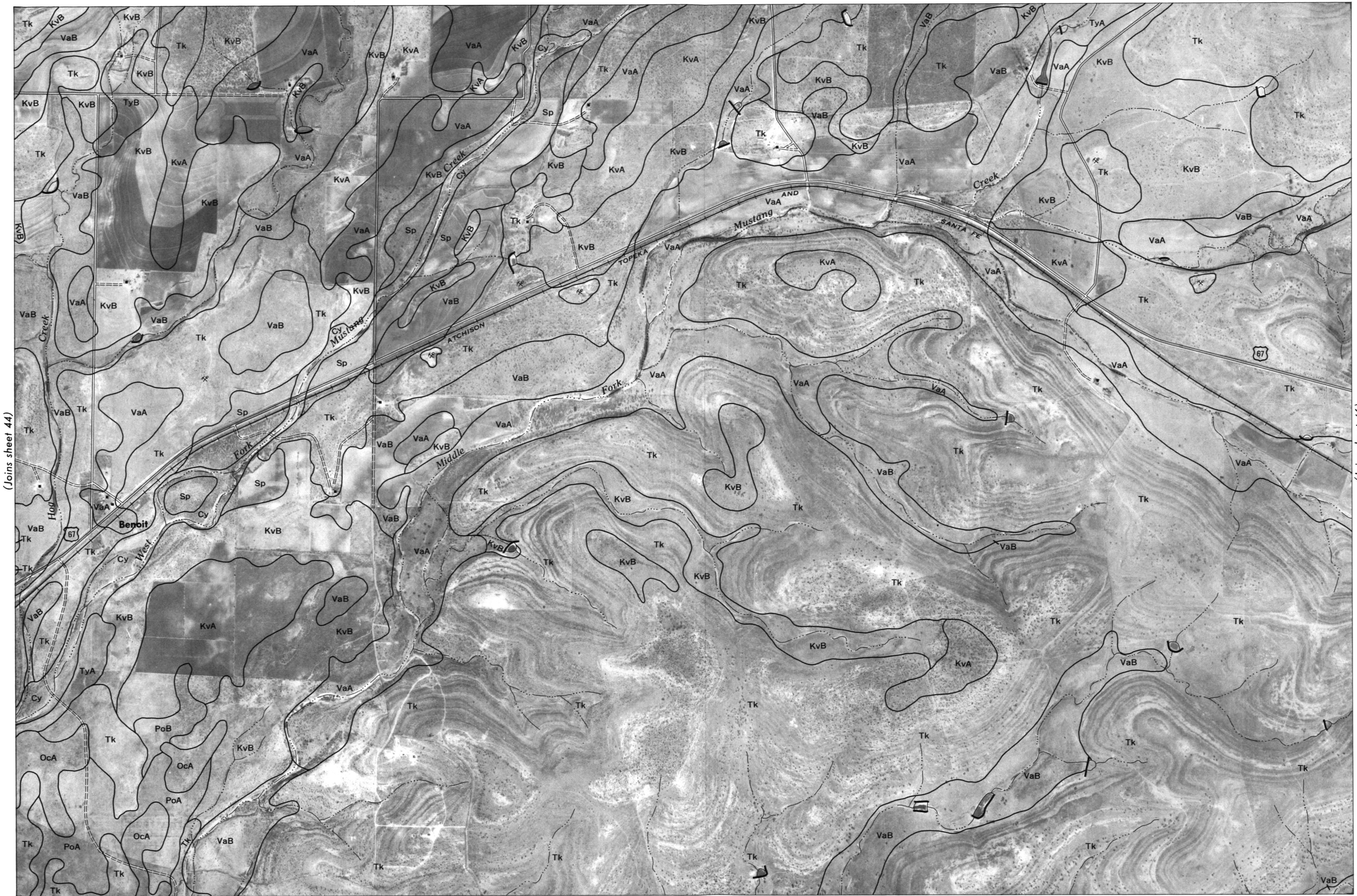
McA (Joins sheet 51)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 39)

(Joins sheet 44)

(Joins sheet 46)



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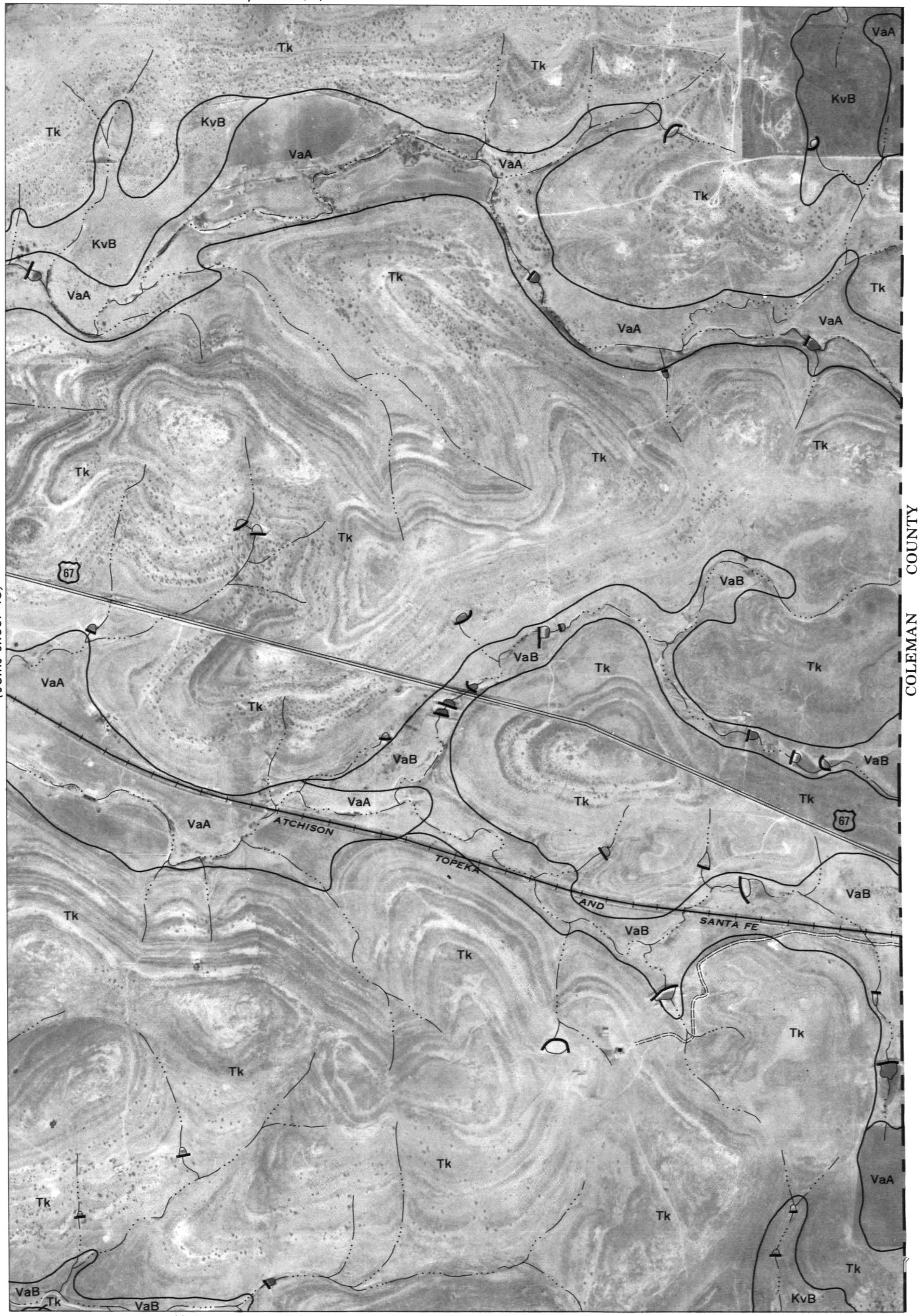
N

(Joins inset, sheet 33)

(Joins sheet 45)



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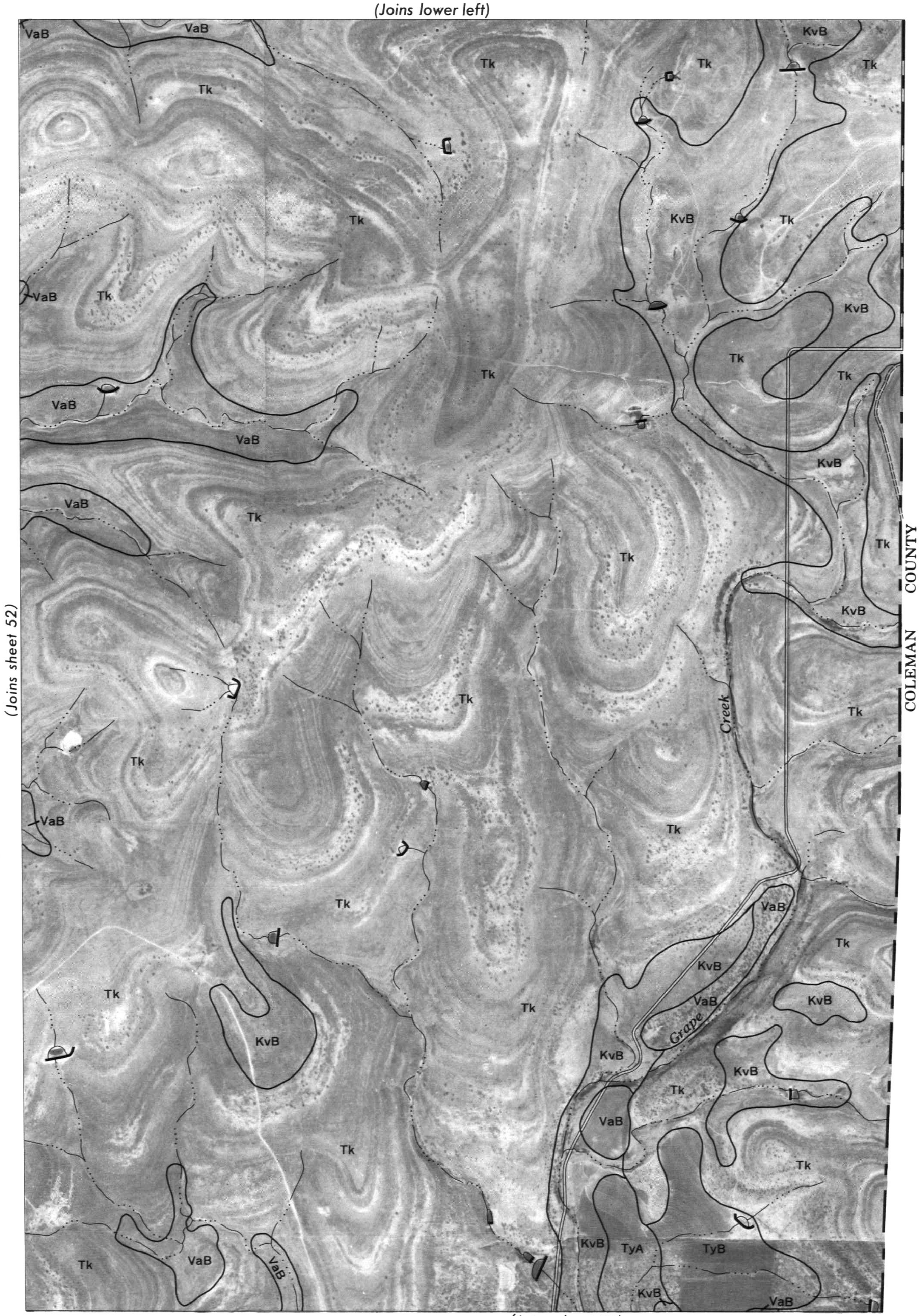
(Joins lower left)

(Joins sheet 52)



(Joins sheet 59)

0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet

(Joins sheet 40)

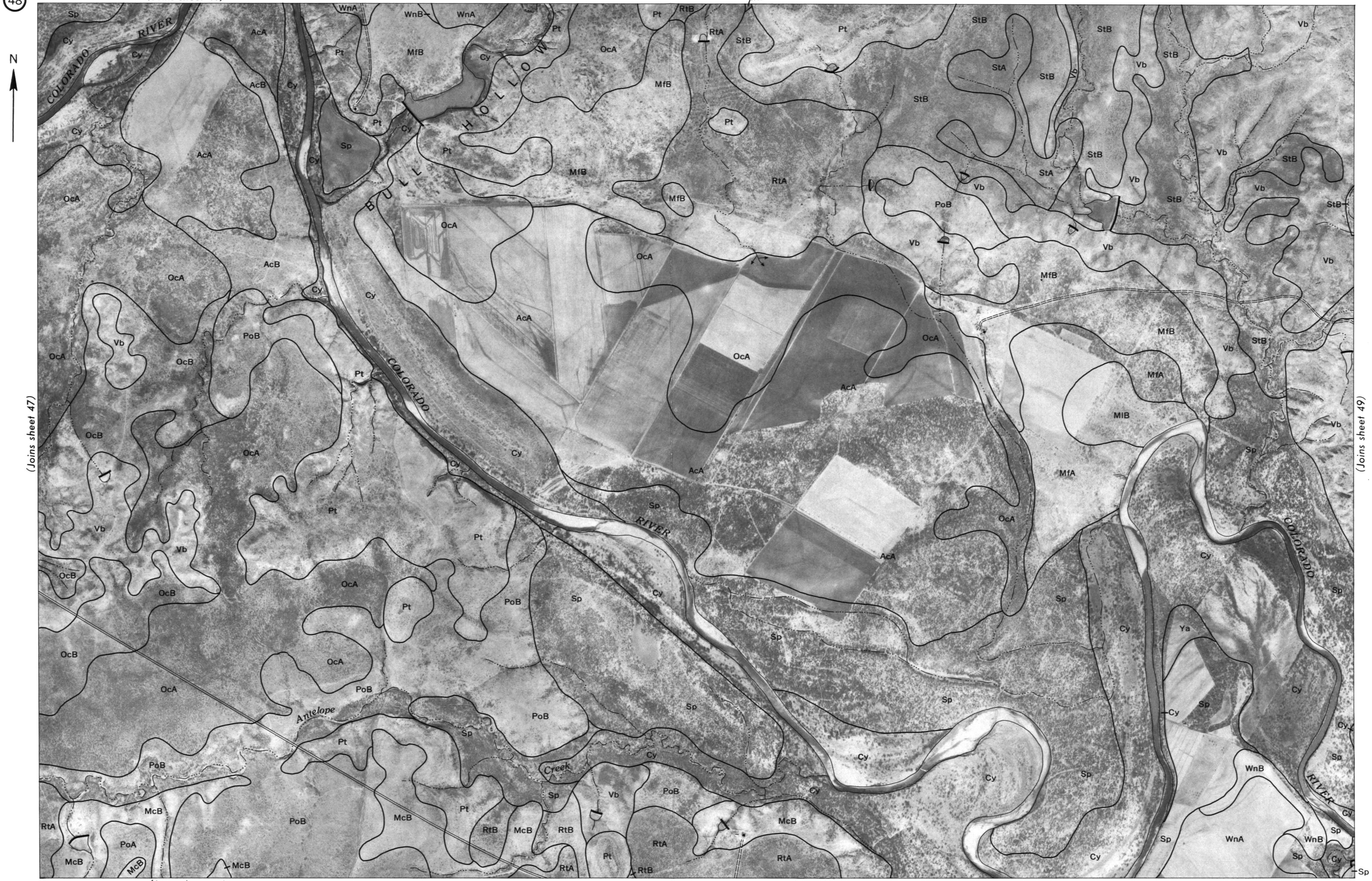
(Joins sheet 48)

(Joins sheet 53)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 48

(Joins sheet 41)



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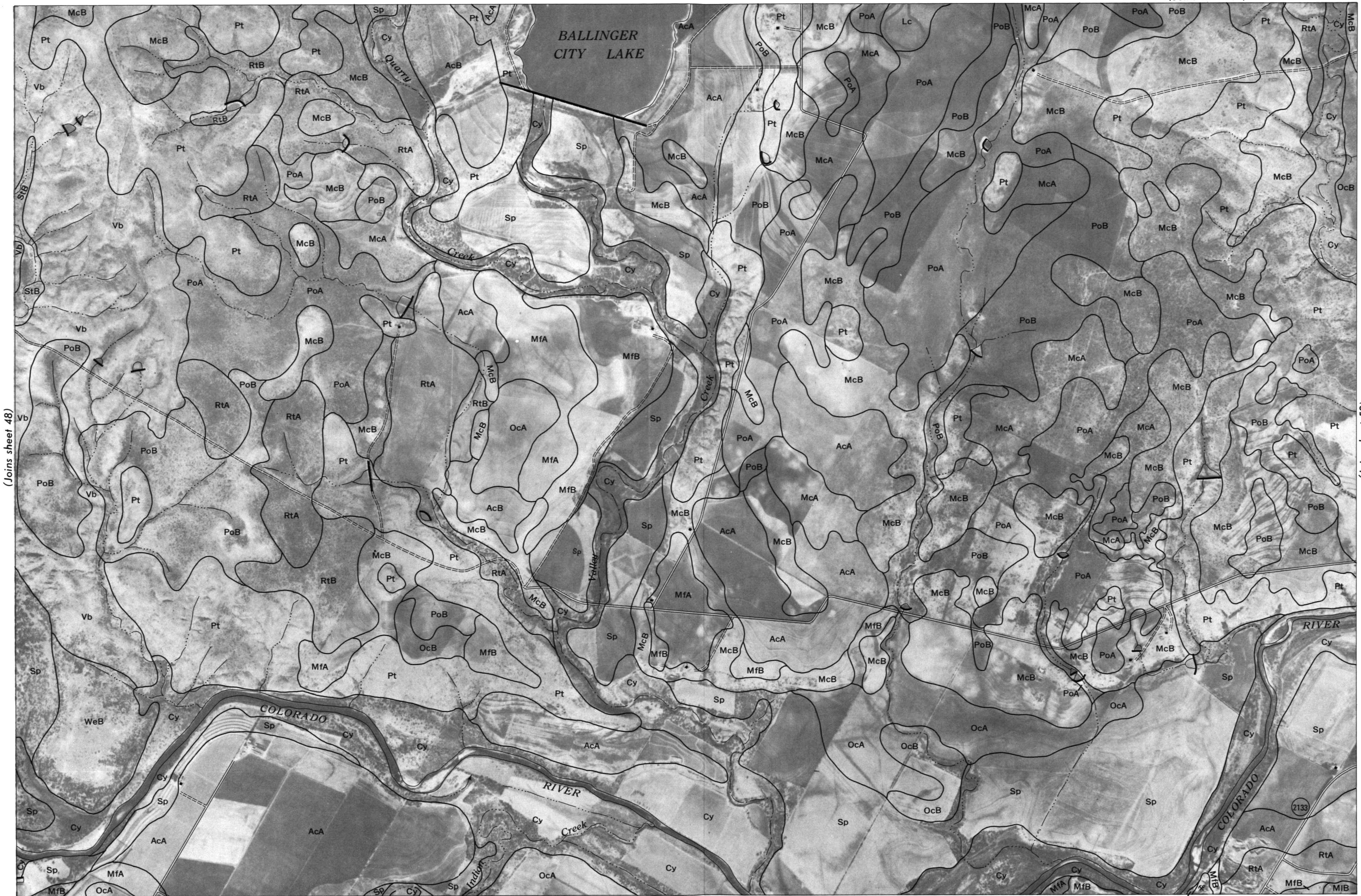
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 42)

(Joins sheet 48)



(Joins sheet 50)

N

(Joins sheet 55)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 43)

N

(Joins sheet 49)

(Joins sheet 51)

(Joins sheet 56)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 44)

(Joins sheet 50)

(Joins sheet 52)

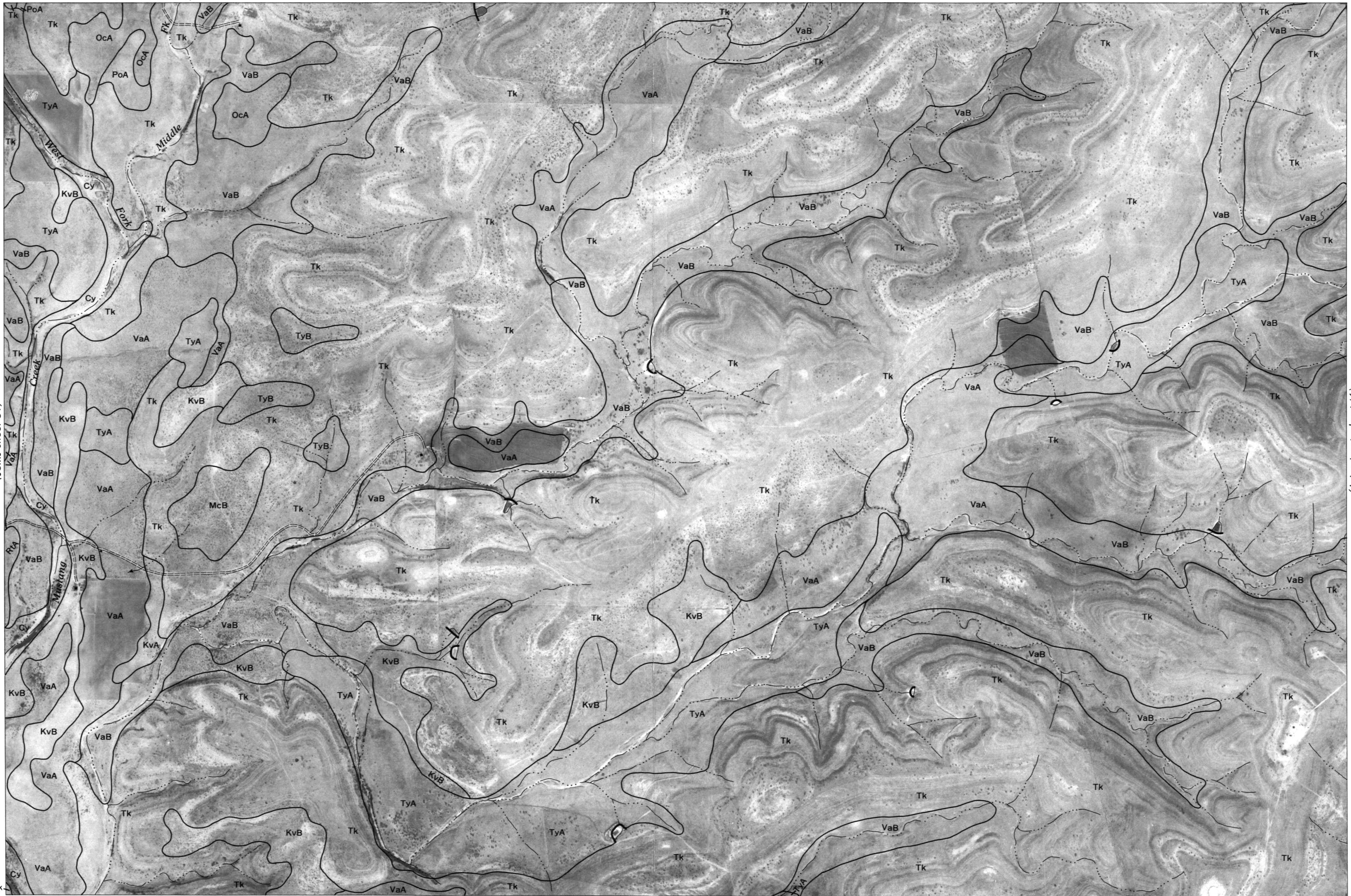
(Joins sheet 57)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

52

(Joins sheet 45)

(Joins sheet 51)



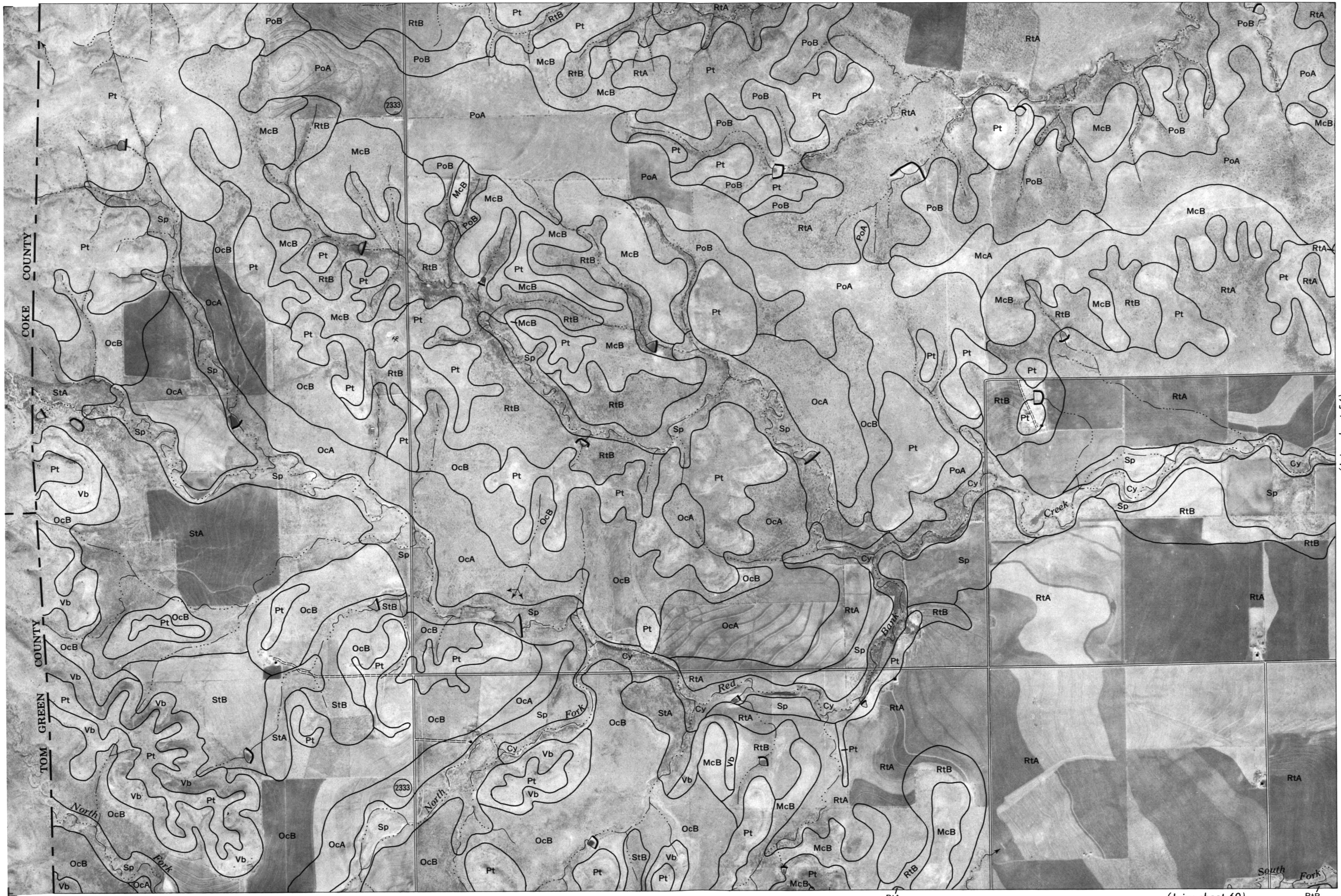
(Joins inset, sheet 46)

(Joins sheet 58)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 47)

53



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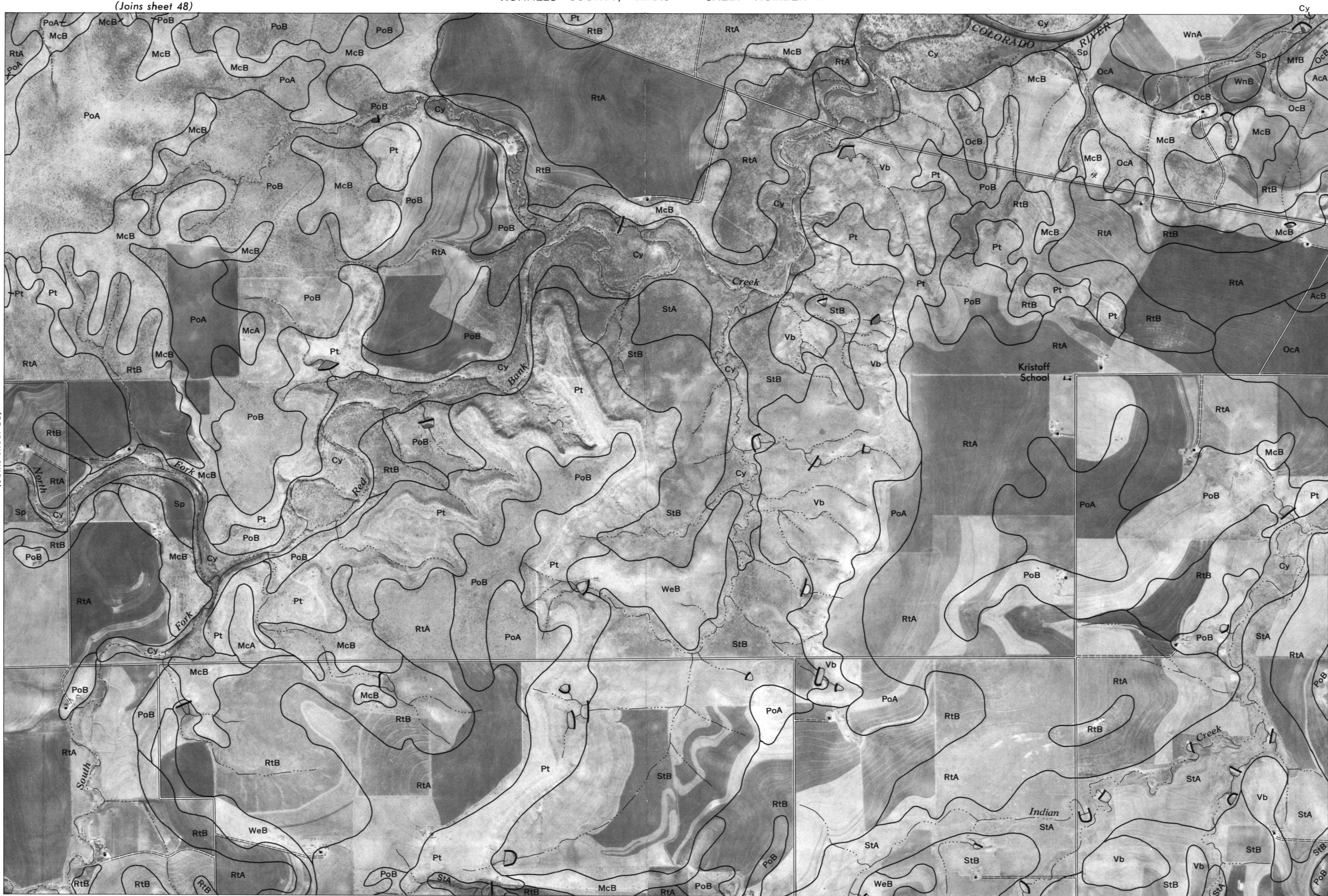
(Joins sheet 60)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 54



0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 49)

(Joins sheet 54)

(Joins sheet 56)

(Joins sheet 62)

0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 56

(Joins sheet 50)

(Joins sheet 55)

(Joins sheet 57)

(Joins sheet 63)

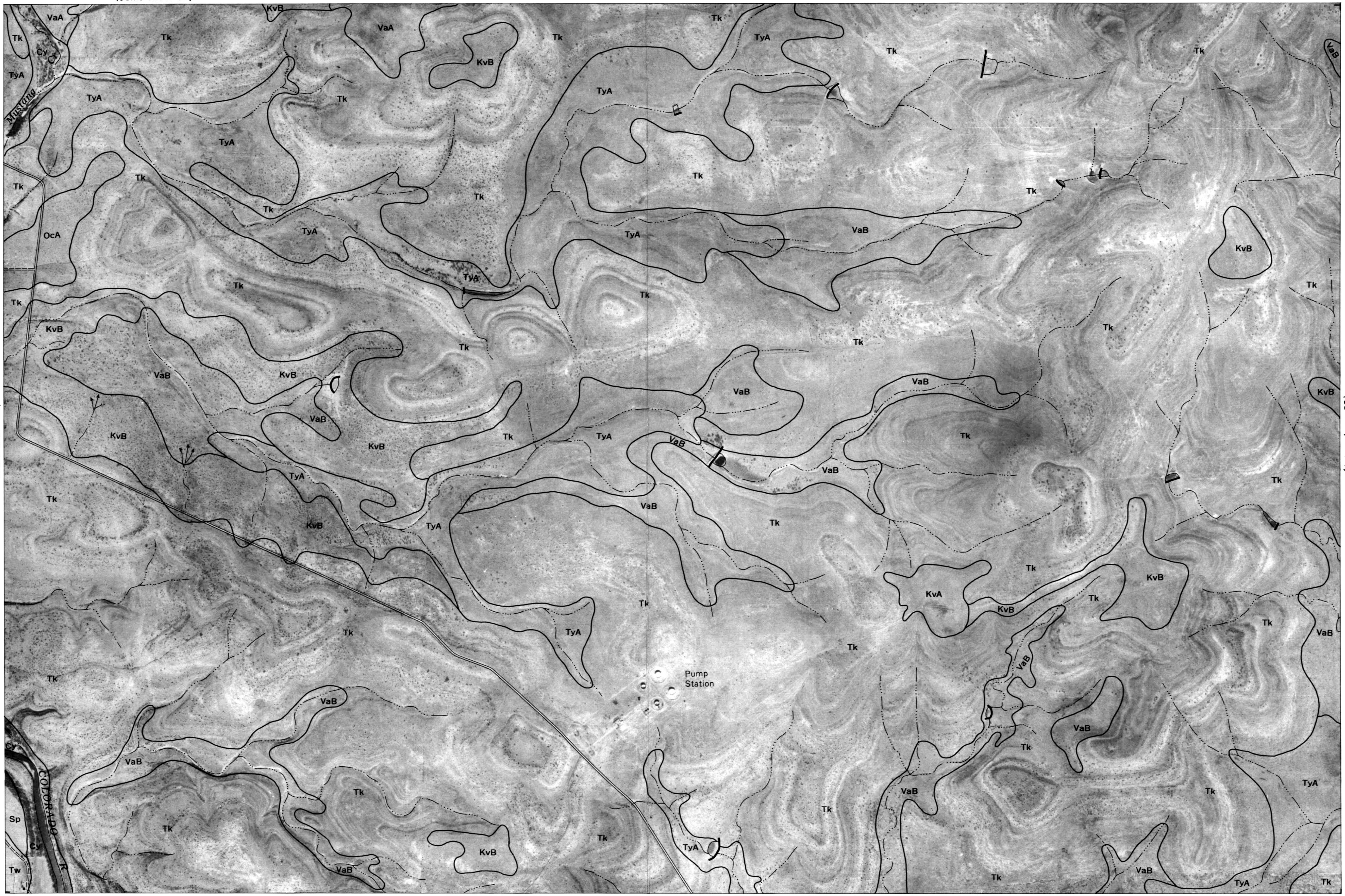
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 58

(Joins sheet 52)

(Joins sheet 57)



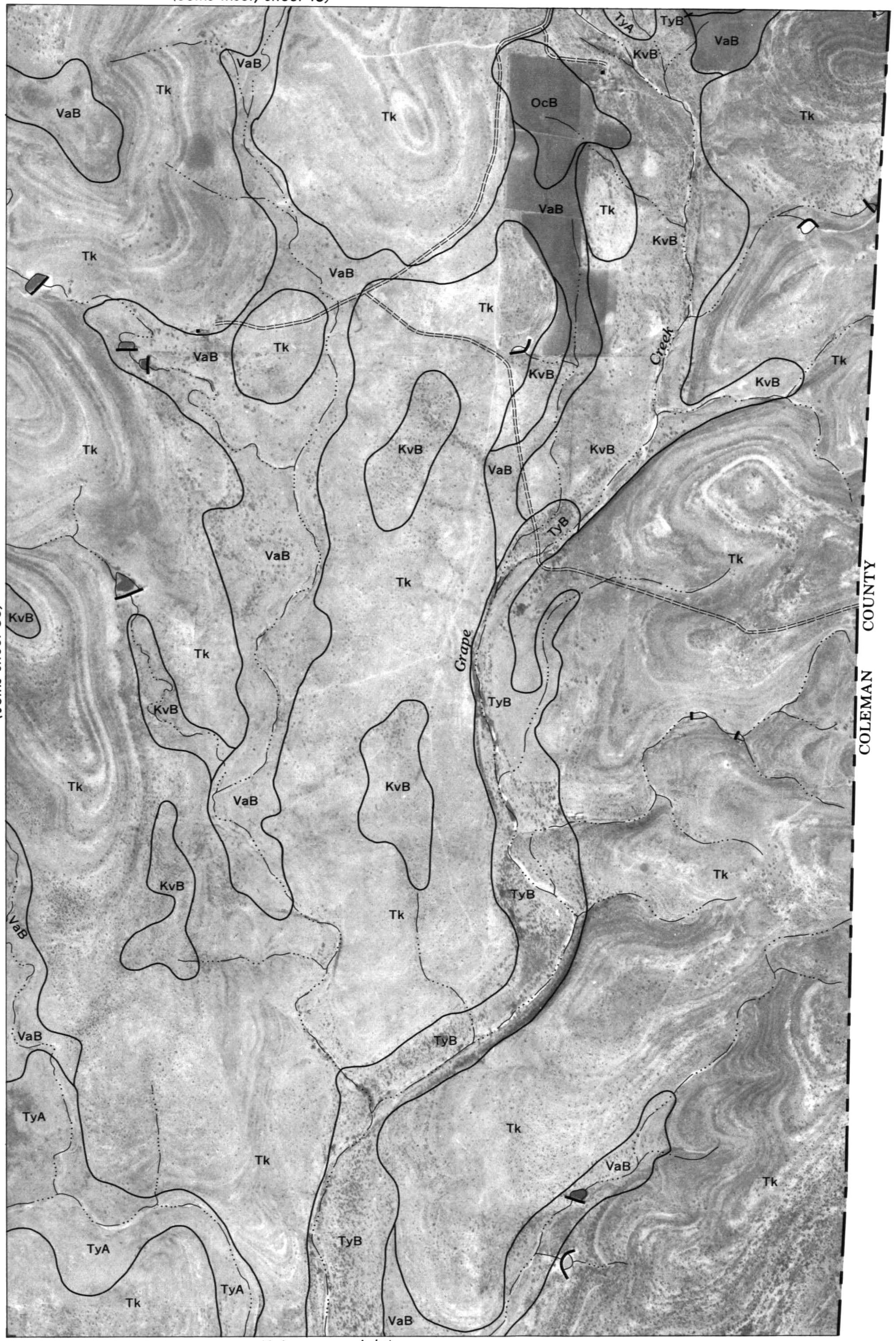
(Joins sheet 59)

(Joins sheet 65)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins inset, sheet 46)

(Joins sheet 58)



(Joins upper right)

(Joins lower left)

(Joins sheet 65)

(Joins sheet 72)

N

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 60

(Joins sheet 53)

(Joins sheet 61)

(Joins sheet 66)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 54)

N

(Joins sheet 60)

(Joins sheet 62)

(Joins sheet 67)

0 ½ 1 Mile Scale 1:20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 62

(Joins sheet 55)

N

(Joins sheet 61)

(Joins sheet 63)

(Joins sheet 68)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

(Joins sheet 56)

(Joins sheet 62)

(Joins sheet 64)

(Joins sheet 69)

0 ½ 1 Mile

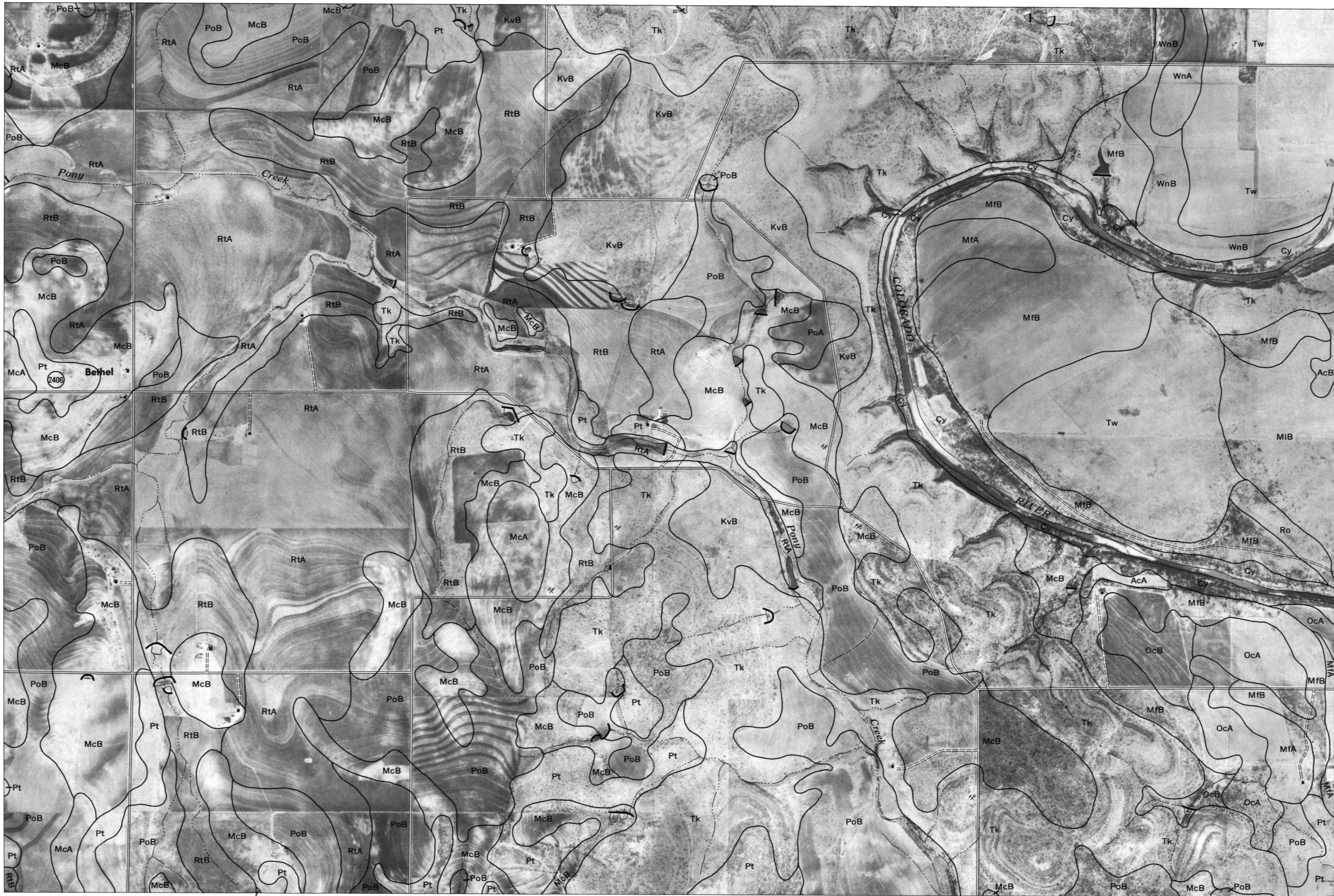
Scale 1: 20 000

0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 64

(Joins sheet 57)

(Joins sheet 63)

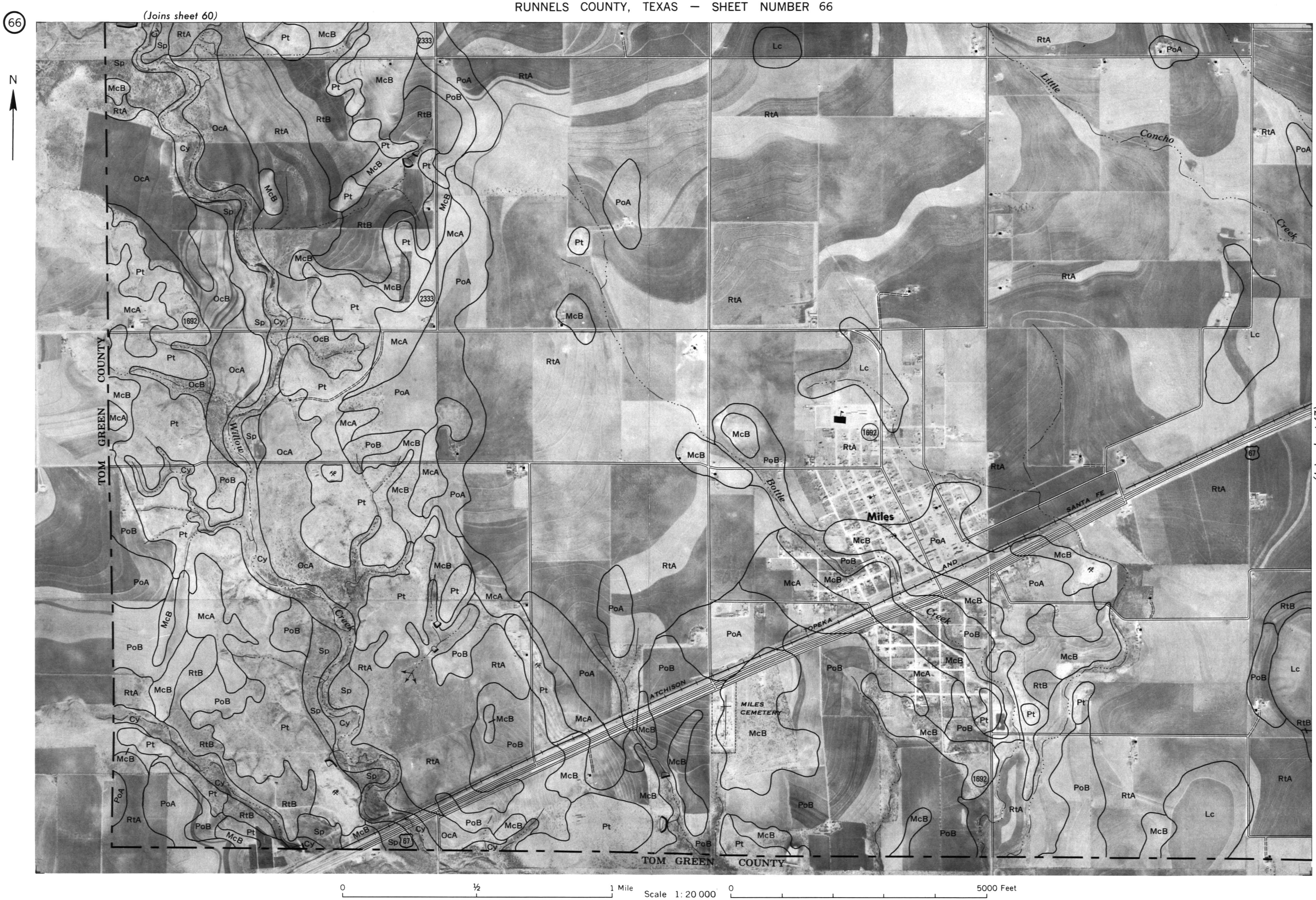


(Joins sheet 65)

(Joins sheet 70)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet


(Joins sheet 58)
(Joins sheet 64)
(Joins inset, sheet 59)
(Joins sheet 71)
N
COLORADO RIVER
COLORADO RIVER
COLORADO RIVER
Tk
VaB
KvB
TyA
AcB
MfA
MfB
MlB
Tw
Cy
Ro
OcA
WnB
VaA
Lc
Pt
Ya
Sp
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet


66
(Joins sheet 60)
N
(Joins sheet 67)
TOM GREEN COUNTY
TOM GREEN COUNTY
Miles
MILES CEMETERY
Little Concho Creek
Willow Creek
Bottle Creek
ATCHISON TOPEKA AND SANTA FE
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet


(Joins sheet 61)
(Joins sheet 66)
(Joins sheet 68)
N
ATCHISON
TOPEKA
AND
SANTA FE
67
Little
Concho
Creek
TOM GREEN COUNTY
CONCHO COUNTY
RtA
RtB
PoA
PoB
Pt
Lc
McA
McB
0
½
1 Mile
Scale 1: 20 000
0
5000 Feet

(Joins sheet 62)

RUNNELS COUNTY, TEXAS — SHEET NUMBER 68

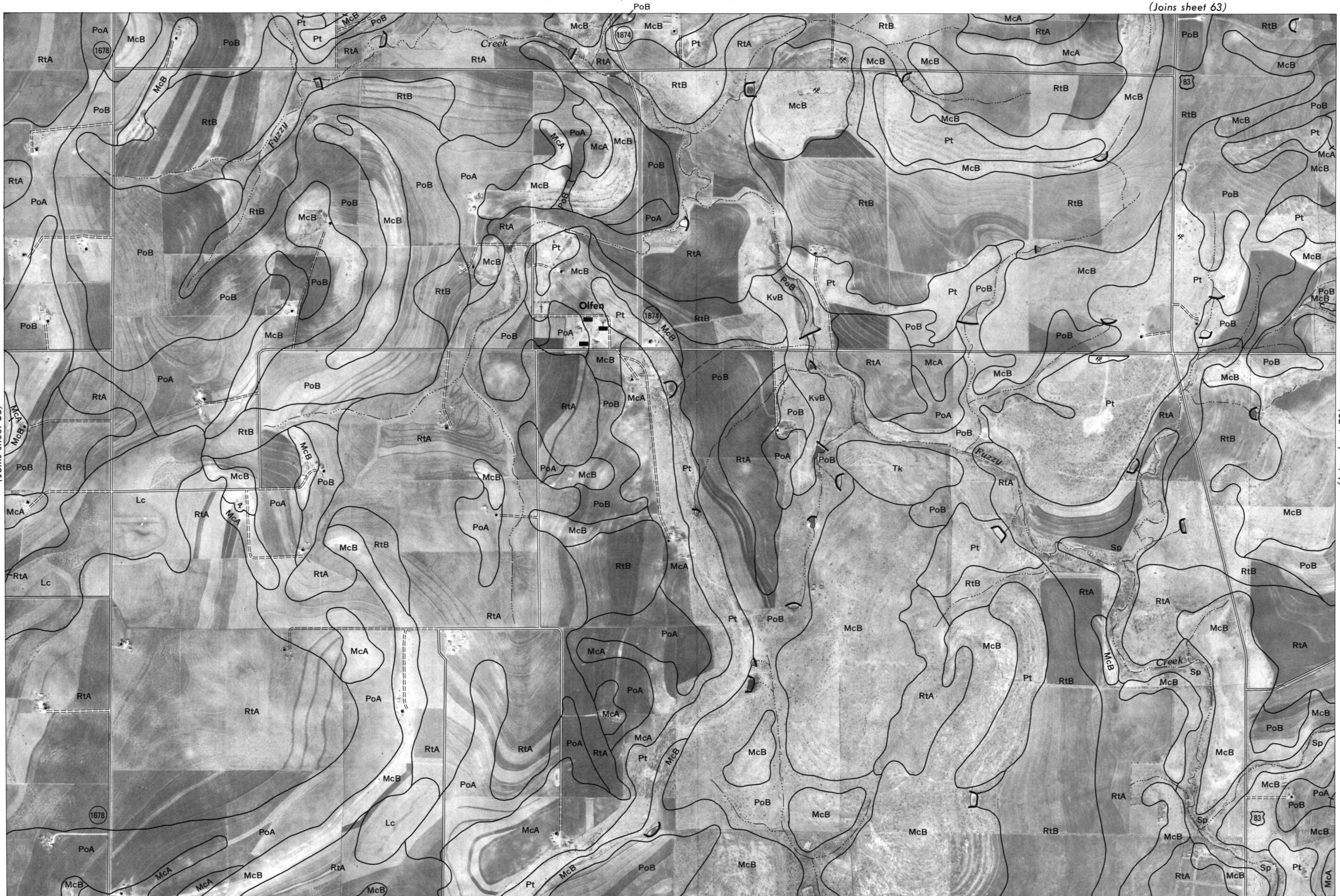
(Joins sheet 67)

(Sh 73)| (Joins sheet 69)

(Joins sheet 63)

(Joins sheet 68)

(Joins sheet 70)



(Joins sheet 73)

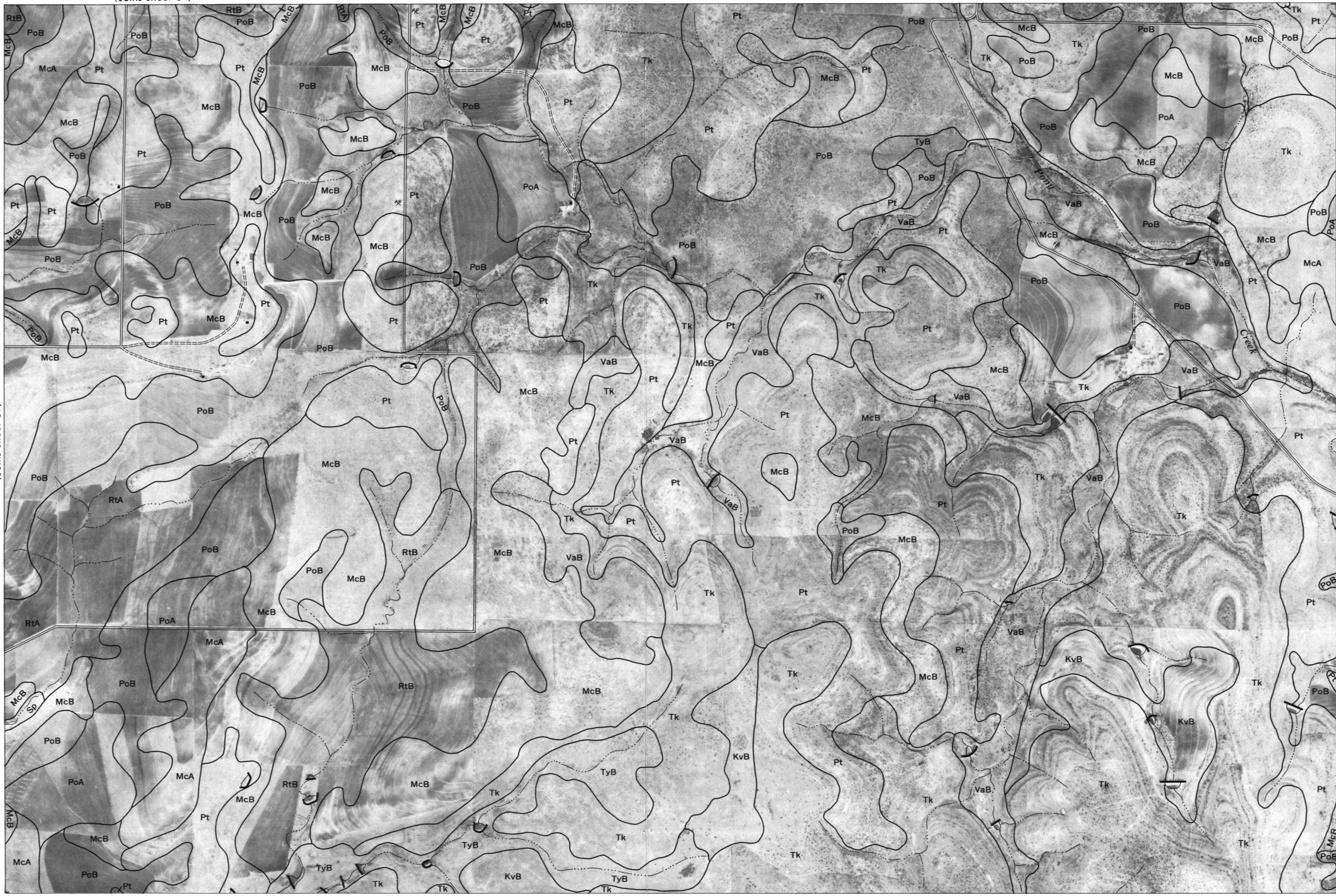
0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

RUNNELS COUNTY, TEXAS — SHEET NUMBER 70

(Joins sheet 64)

N

(Joins sheet 69)



(Joins sheet 71)

(Joins inset A sheet 73)

0 ½ 1 Mile

Scale 1: 20 000

0 5000 Feet

(Joins sheet 65)

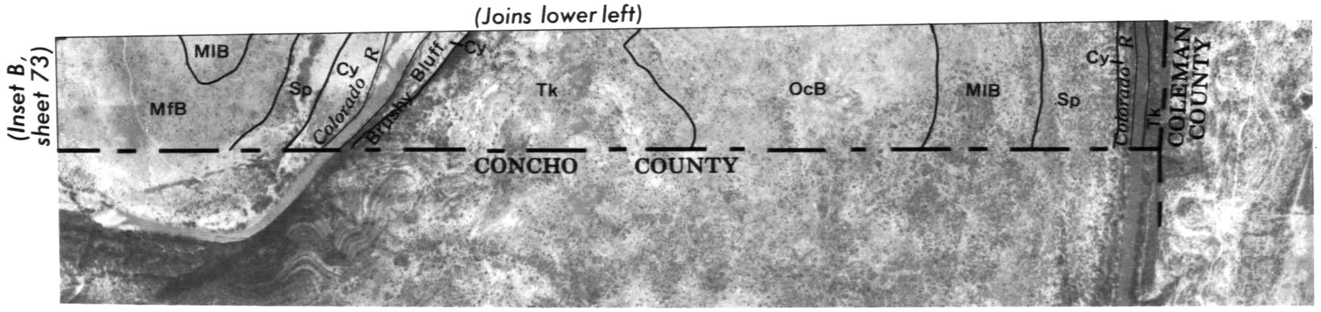
(Joins sheet 70)

(Joins sheet 72)

(Joins inset B, sheet 73)

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet

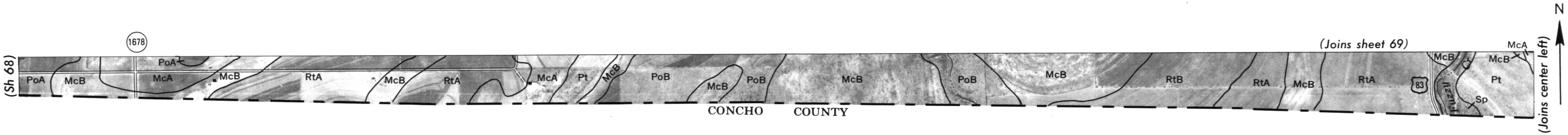
N

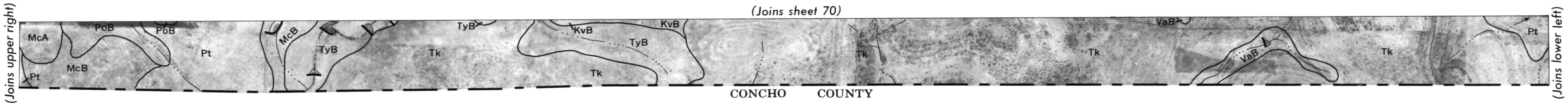


0 ½ 1 Mile

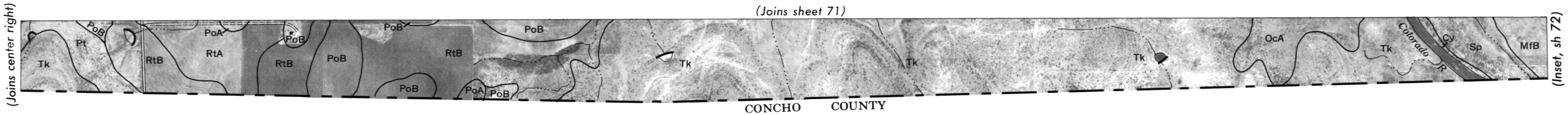
Scale 1: 20 000

0 5000 Feet





INSET A



INSET B

0 ½ 1 Mile Scale 1: 20 000 0 5000 Feet